[redacted]

WT-609

Copy No. 151 A

Operation IVY

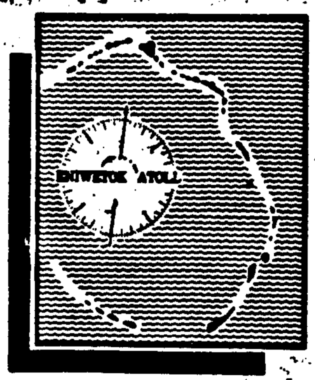
PACIFIC PROVING GROUNDS

DIL019003

November 1952

Project 10.1

TIMING AND FIRING AND FIDUCIAL MARKERS



[redacted]

JOINT TASK FORCE 132

[redacted]

[redacted]

Defense Nuclear Agency
6801 Telegraph Road
Alexandria, Virginia 22310-3398

ISST

30 May 1996

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION CENTER
ATTENTION: OCD/Mr. Bill Bush

SUBJECT: DOCUMENT FOR INCLUSION IN DTIC/NTIS.

The Defense Nuclear Agency Security Office (OPSSI) has reviewed and declassified the following report:

WT-609
Operation IVY
Pacific Proving Grounds
November 1952
Project 10.1, Timing and Firing and Fiducial Markers.

The distribution statement is approved for public release or statement "A."

Since no record is available to show DTIC received a copy of this report, this office has included a copy for inclusion into DTIC/NTIS.

Ardith Jarrett
ARDITH JARRETT
Chief, Technical Support

Enclosure:
A/S

UNCLASSIFIED [redacted]

WT-609

This document consists of 69 pages

No. 151 of 210 copies, Series A

Report to the Scientific Director

TIMING AND FIRING AND FIDUCIAL MARKERS

By

H. E. Grier

and Staff

Edgerton, Germeshausen & Grier, Inc.
Boston, Massachusetts
March 1953

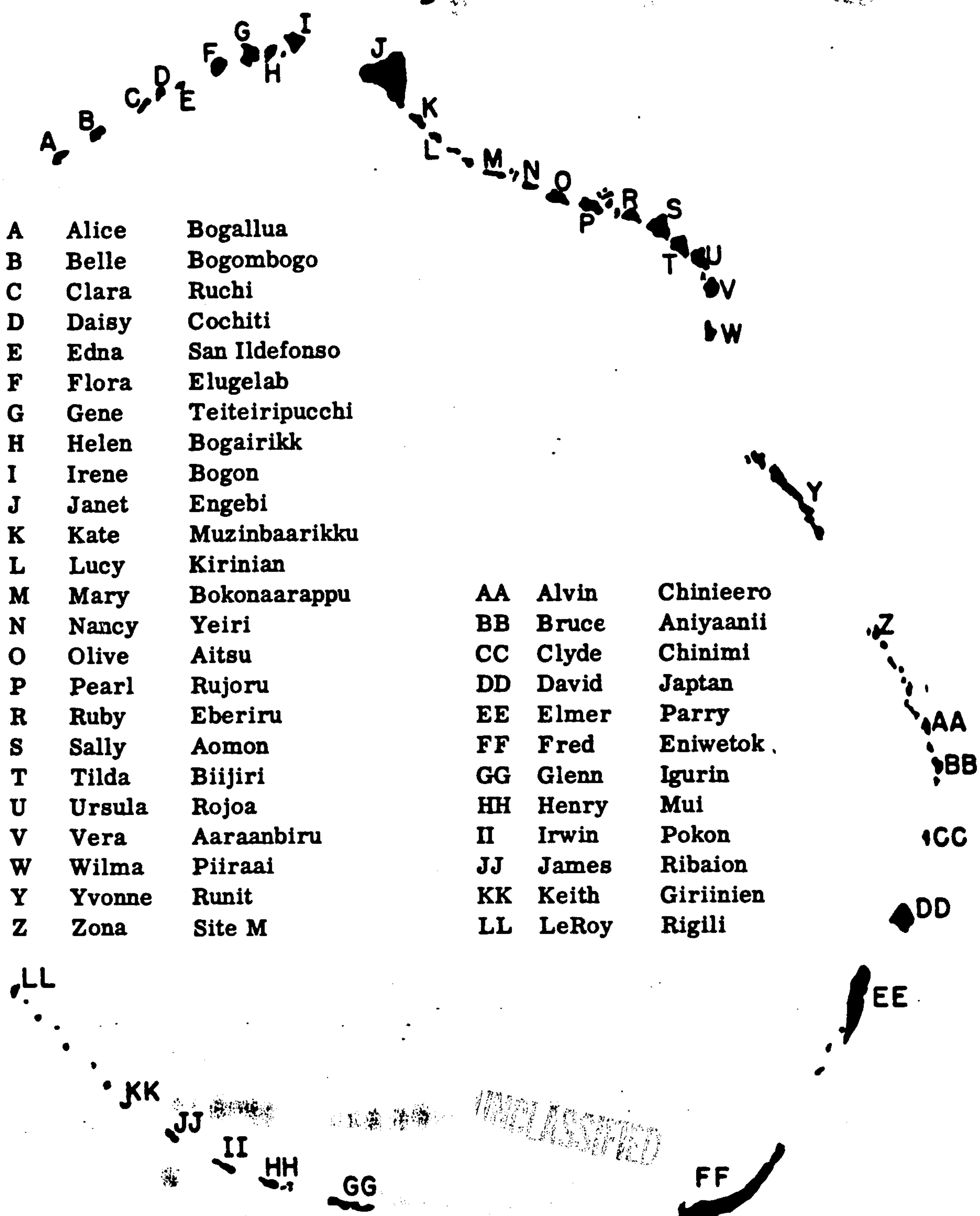
[redacted]

UNCLASSIFIED

[redacted]

[redacted]

UNCLASSIFIED



A	Alice	Bogallua	AA	Alvin	Chinieero
B	Belle	Bogombogo	BB	Bruce	Aniyaanii
C	Clara	Ruchi	CC	Clyde	Chinimi
D	Daisy	Cochiti	DD	David	Japtan
E	Edna	San Ildefonso	EE	Elmer	Parry
F	Flora	Elugelab	FF	Fred	Eniwetok
G	Gene	Teiteiripucchi	GG	Glenn	Igurin
H	Helen	Bogairikk	HH	Henry	Mui
I	Irene	Bogon	II	Irwin	Pokon
J	Janet	Engebi	JJ	James	Ribaion
K	Kate	Muzinbaarikku	KK	Keith	Giriinien
L	Lucy	Kirinian	LL	LeRoy	Rigili
M	Mary	Bokonaarappu			
N	Nancy	Yeiri			
O	Olive	Aitsu			
P	Pearl	Rujoru			
R	Ruby	Eberiru			
S	Sally	Aomon			
T	Tilda	Biijiri			
U	Ursula	Rojoa			
V	Vera	Aaraanbiru			
W	Wilma	Piiraai			
Y	Yvonne	Runit			
Z	Zona	Site M			

UNCLASSIFIED

ENIWETOK ATOLL

[redacted]

UNCLASSIFIED

ABSTRACT

Project 10.1 was set up for the purpose of providing a remote-control system capable of arming, firing, and monitoring vital information from a surface-detonated device. It provided accurate timing signals to a group of stations scattered about the atoll for both a surface shot and an airdrop. It also made a provision for zero world-time determination.

Mike Shot was armed and fired by means of a remote-control system from a control station aboard the U. S. S. *Estes*. A radio signal from this control station started the sequence timer at the central control station, which, in turn, initiated a series of timing signals to various experimenters and armed and fired the device. Certain information of importance to cryogenics groups and the firing party was monitored by means of a microwave television system, with the receiver located aboard the U. S. S. *Estes*. Zero time was given to other experimenters by means of fiducial markers, Blue Boxes, and radio tones.

King Shot timing procedure was similar to that of previous airdrops. This shot required no television coverage, and the central Control Point (CP) was located on Parry Island.

Results on both shots were satisfactory with the exception of the operation of the Blue Boxes, some of which failed to trigger, primarily owing to the unexpected low light level. The performance of the system used on Operation Ivy proved both reliable and accurate and appears well justified for use on future operations of this sort.

UNCLASSIFIED

[redacted]

[redacted]

CONTENTS

[redacted]

[redacted]

CONTENTS (Continued)

ILLUSTRATIONS

[redacted]

[redacted]

ILLUSTRATIONS (Continued)

Page

CHAPTER 4 RADIO-TONE SIGNALS

CHAPTER 5 BLUE BOXES AND FIDUCIAL MARKERS

APPENDIX WIRING DIAGRAMS

TABLE

CHAPTER 2 TIMING AND FIRING SYSTEM

[redacted]

[redacted]

CHAPTER 1

GENERAL OBJECTIVES, BACKGROUND, AND SCOPE

1.1 OBJECTIVES

The timing and firing program had two principal objectives: The first was to provide remote-control equipment that would arm and fire a surface-detonated device with a high degree of reliability, and the second was to provide experimenters with an accurate sequence of timing signals based on zero time for the purpose of starting or stopping their equipment. Closely associated with these two aims were three other projects: (1) determination of an accurate world time for time of burst, (2) provision of personnel as members of the firing party, and (3) installation of a system capable of monitoring vital information from the zero site to the control ship. Experience gained on previous operations has proved the effectiveness of a system designed along the lines used on Operation Ivy.

Mike Shot was similar to the Greenhouse detonations in that it was detonated at a fixed point, and required both a timing and a firing system. Due to the nature of Mike Shot, a somewhat different method of initiating an arming and firing signal and of monitoring vital information from the zero station was required and was incorporated within the system. However, the basic system remained essentially the same as the one used on Greenhouse.[1] King Shot, on the other hand, was an aerial burst fused to fire at a predetermined height, thus eliminating a firing circuit and leaving the timing and firing group responsible only for providing timing signals.

1.2 BACKGROUND

The concept of a centralized control station sending signals via submarine cable links to distribution stations on the islands and thence to the experimenters was tested and proved on Sandstone[2] and Greenhouse.[1] The combination of an electrically driven cam timer to send signals and heavy-duty DN-11 relays to actuate or control distribution circuits was demonstrated to be both serviceable and reliable. Basically, this system was again used on Ivy with some modifications and additions necessary because of the nature and size of the detonations. Telephone cables and control and signal cables are shown in Figs. 1.1 and 1.2, respectively.

1.3 SCOPE

The equipment used at Greenhouse was shipped to the Nevada Proving Grounds where it was modified to suit local conditions, therefore making it necessary to design and build new equipment for use on Operation Ivy. The basic system employed was similar to that used on Greenhouse but with some important modifications and additions. The control and zero stations

[redacted]

[redacted]

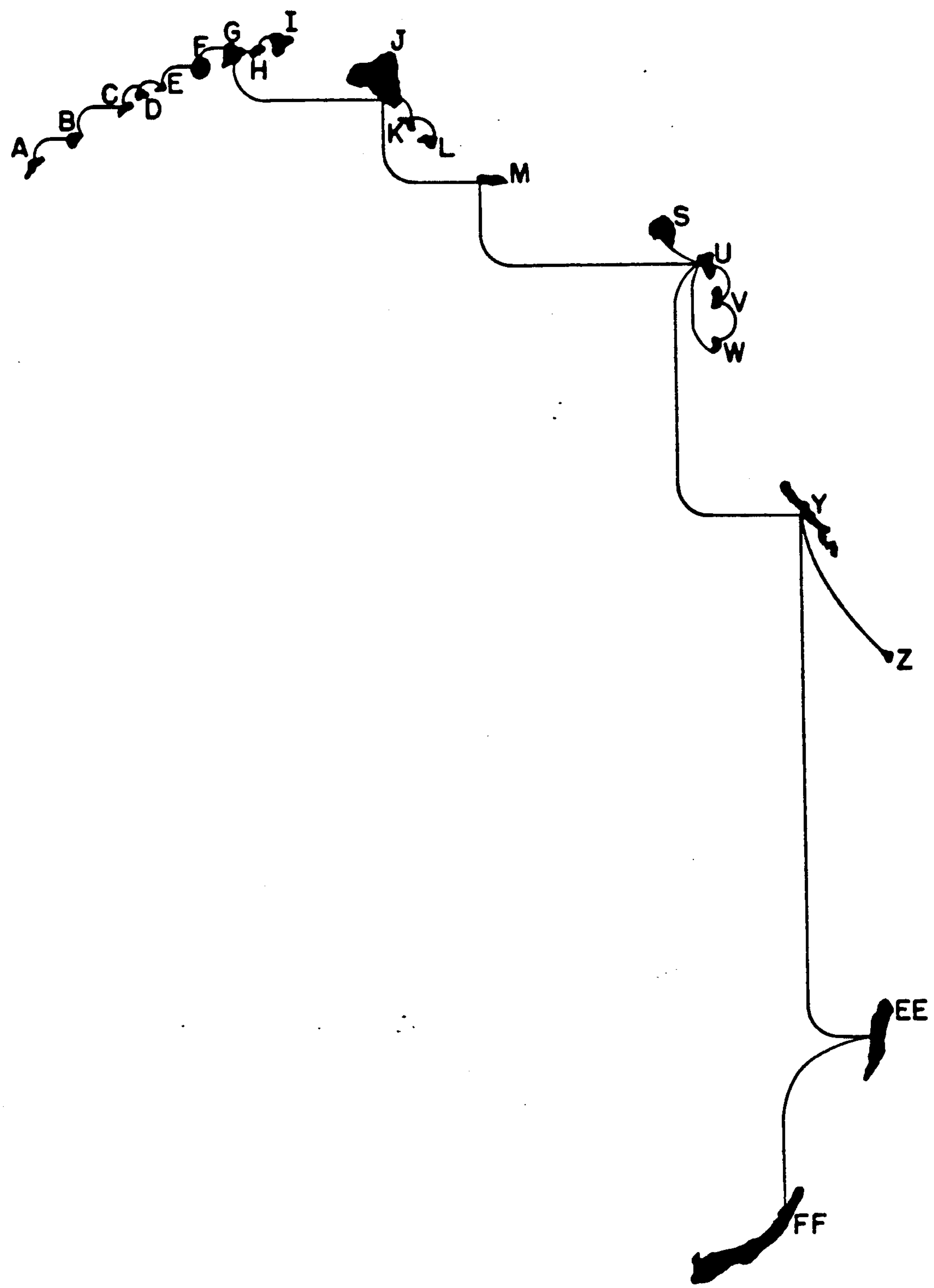


Fig. 1.1—Physical layout of telephone cables.

[redacted]

[redacted]

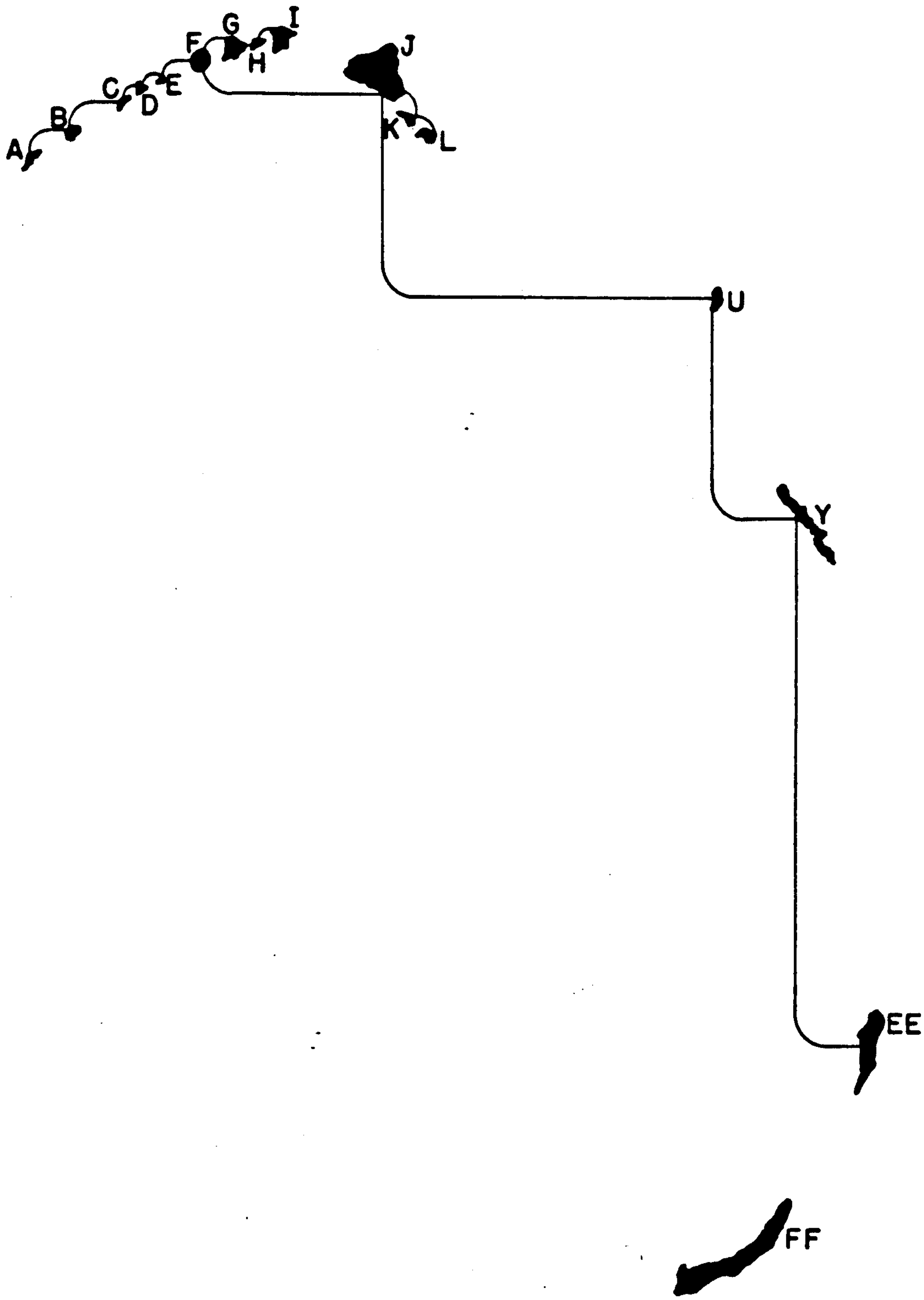


Fig. 1.2—Physical layout of control and signal cables.

[redacted]

[redacted]

for Mike Shot were combined on Flora, and signals were sent to auxiliary timer stations on adjacent islands where they were distributed and relayed to other stations. Mortar-Jato raft stations located in the lagoon received signals delivered via radio for the purpose of firing smoke-puff mortars. Monitoring of vital information from site zero was done by a microwave television link, and hand signals starting the sequence timer and emergency stop were controlled by radio-transmitted signals. The auxiliary timer stations were necessary in order to reduce the number of submarine cables required between the shot island and the adjacent islands. Radio-tone signals to raft stations were employed instead of laying new submarine cable, the cost of which would have been prohibitive. Likewise, starting of the sequence timer was done via radio and monitoring via television because it was deemed unsafe for the firing party to fire the bomb from Elmer, and cable laying from Elmer to a ship at sea was considered impractical and costly. For Operation Ivy the following number of stations were required (excluding spares): one ship control and monitoring station, one main control and zero station, and seven auxiliary timer stations.

REFERENCES

1. Greenhouse Report, Annex 1.11, Timing and Firing and Fiducial Markers, WT-99.
2. Sandstone Report, Annex 3, Part 1, Sec. 2, Vol. 15.

[redacted]

[redacted]

CHAPTER 2

TIMING AND FIRING SYSTEM

2.1 EQUIPMENT PREPARATION

Experience on previous operations has proved the value of preassembly of as much equipment as possible before shipment to the field. This not only assures the availability of a better quality of equipment but saves countless hours of labor doing a job under field conditions. Thus a great deal of the timing and firing equipment was assembled and wired internally in Boston and shipped intact to the site where it was to be used. Personnel of Edgerton, Germeshausen & Grier, Inc. (EG&G) arriving at the atoll were able to proceed immediately with setup procedures, using this equipment as it was uncrated. Another no less important feature of having equipment preassembled was the morale effect on the installation crew. Setting up and wiring a completed unit is much less of a problem than doing that job coincident with assembly and testing of equipment.

2.2 BASIC TIMING CIRCUIT, MIKE SHOT

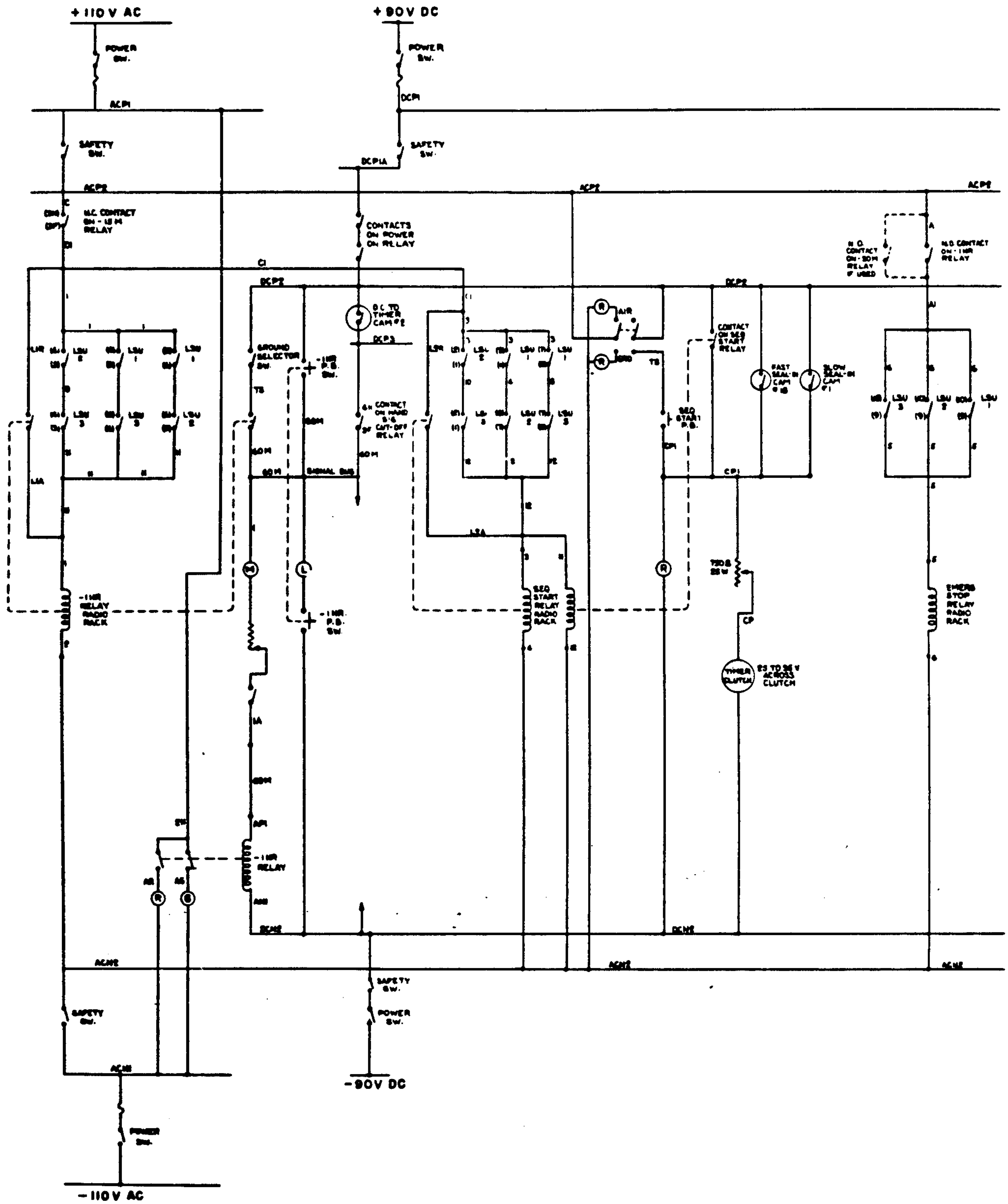
The basic timing and firing system is shown in the schematic diagram in Fig. 2.1. The basic hold-in circuit appears in Fig. 2.2. This hold-in system works as follows: When the mercury switch closes, a current flows through a milliammeter, an adjustable resistor, and a master relay. The resistor is adjusted so that a current of 30 ma flows through the relay, producing 30 volts across the master relay coil. The resistor compensates for line resistance and equalizes the voltage across all relays, thereby making the operating times equal.

The circuit shown in Fig. 2.2 is quite similar to that employed on Greenhouse, with several modifications. Since the central control station and zero station were combined on Mike Shot and were destroyed at zero time, it was necessary to install cam timers in several of the auxiliary stations to provide a hold-in circuit capable of producing signals after zero time. Closure of the cam-operated mercury switch in the master relay circuit energized coil L_1, closing DN-11 contacts 1 and 2. Closure of contact 2 completes the circuits to a number of auxiliary relays located at experimental stations. These auxiliary relays are similar to the master relay in that a meter, a resistor, and a disconnect switch are included in each relay circuit. During dry runs the operation of each circuit is readily checked by observing the meters. The purpose of the disconnect switch is to open the circuit of any experimenter who does not wish to participate in the dry run.

Closure of contact 1 starts the cam motor in the distribution stations. At a prearranged time (before zero time) the mechanical cam contacts 3 and 4 close, completing the alternate circuit driving the cam motor and energizing the coil L_2, respectively. At zero time, the control station is destroyed, and coil L_1 is deenergized. However, coil L_2 is still energized

[redacted]

[redacted]



[redacted]

[redacted]

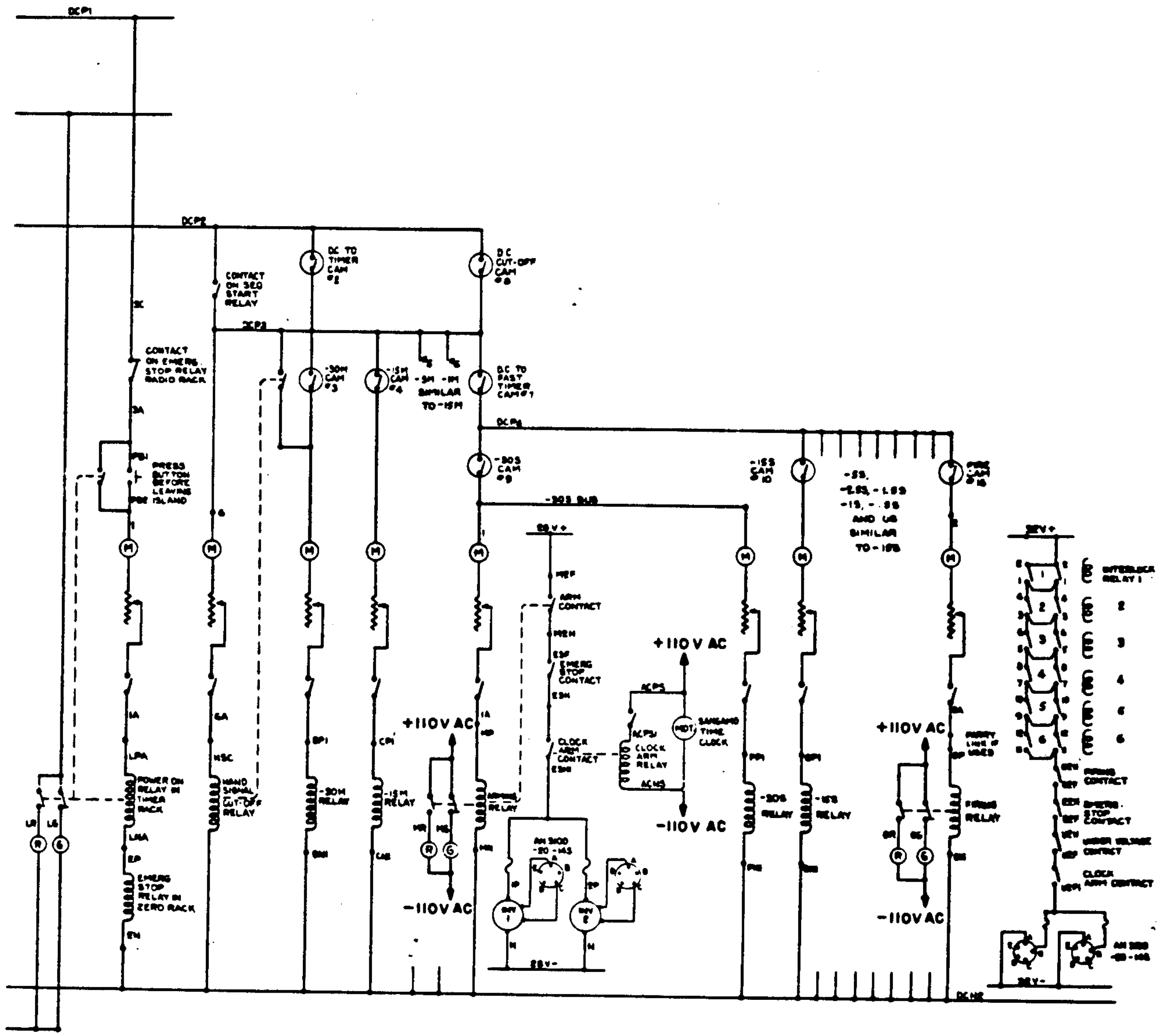


Fig. 2.1—Schematic diagram of basic timing and firing system.

[redacted]

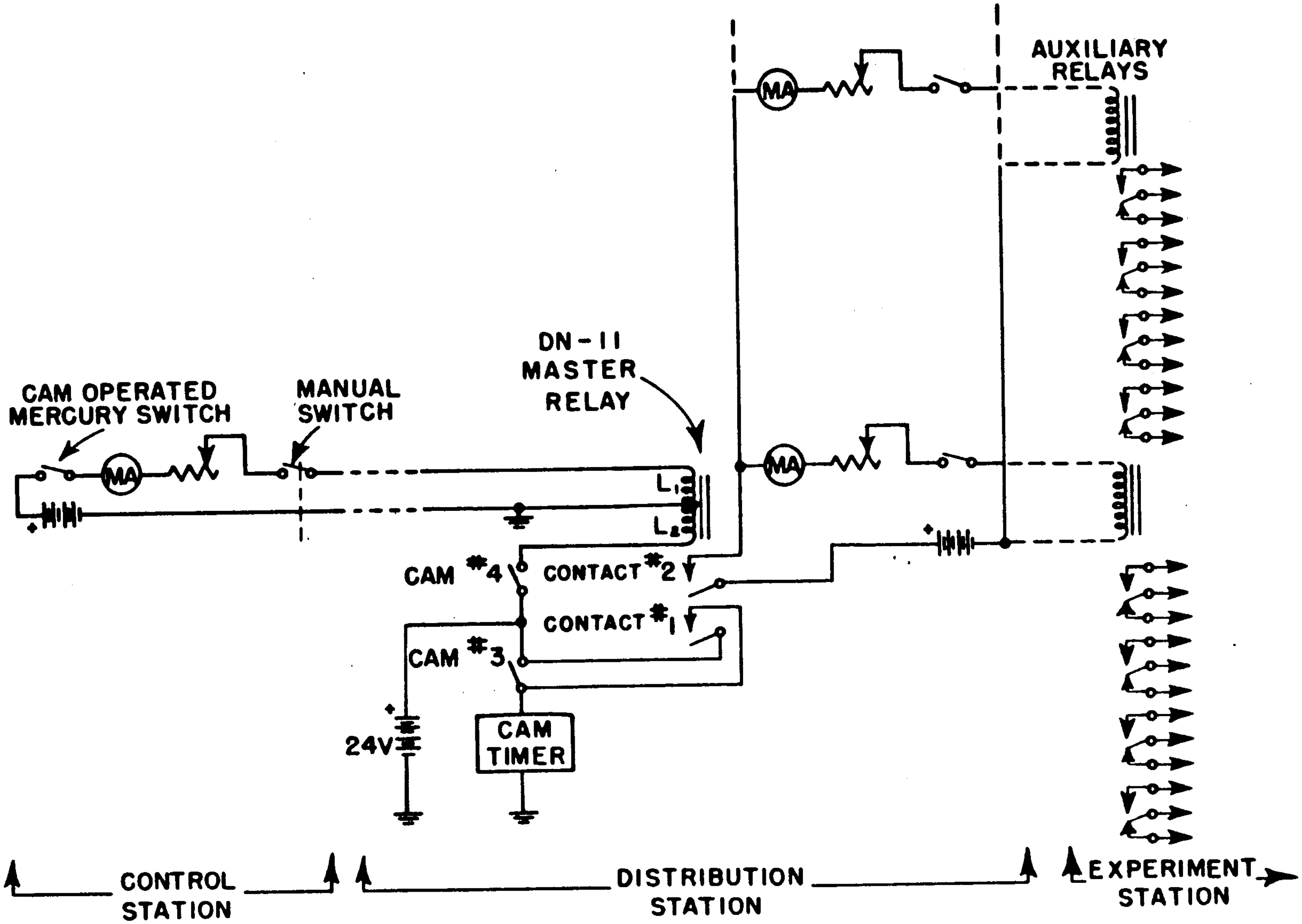


Fig. 2.2—Basic hold-in circuit used on Mike Shot.

[redacted]

[redacted]

through contact 4, and therefore the relay contacts remain closed until cam 4 opens at a predetermined time after zero (+1 sec). Cam 3 remains closed until the timer has completed a cycle; then the cam opens and the timer stops and is ready for the next cycle.

2.3 APPARATUS AND PROCEDURES

2.3.1 Control and Zero Station, Mike Shot

The control and zero stations were combined on Mike Shot, and the resulting station consisted of eight enclosed relay racks set in a row along one side of a 24- by 24-ft air-conditioned room adjacent to the bomb cab. The remainder of this room was occupied by the television panels and television-camera chain equipment.

Rack 1, the power rack (wiring diagram shown in Fig. A.1), contained all the switches and meters for indicating and controlling the a-c and d-c power required to operate the station. It also contained the Brush 60-cycle regulated power supply which supplied power to the timer motor, time clocks, and clock arming switch.

Rack 2, the timer rack (wiring diagram shown in Fig. A.2), contained a time clock, monitor lights, sequence timer, safety switch, and control switches. The time clock ran off the Brush power supply and was checked at regular time intervals with station WWVH for accurate time. The monitor lights indicated the position of the d-c hold-in relay which, when closed, held the d-c power on. However, when an emergency stop signal was sent, the contacts opened, cutting off all d-c power and disabling the system. In the event that this should happen, it would be necessary to return to the station to reactivate the circuit. The control switches governed the starting of the cam timer, and when the safety switches were open no signals could emanate from the station.

Rack 3, the test rack (wiring diagram shown in Fig. A.3), contained only the recording clocks. When the cam timer was started, these clocks would indicate when each contact closed and the length of time each remained closed.

Rack 4, the signal-distribution rack (wiring diagram shown in Fig. A.4), contained indicating milliammeters, adjustable resistors, and switches. Signals from the sequence timer were distributed and fed through the milliammeters, resistors, and switches to the proper lines in the submarine cables. Each pair of wires in the submarine cable terminated with a DN-11 relay at auxiliary stations on adjacent islands. The signal-distribution rack also distributed signals to the local relay rack for the indicating lights on the television panel. In addition, it distributed signals to local experimental stations. Each line could be disconnected from the rack by means of a toggle switch.

Rack 5, the relay rack (wiring diagram shown in Fig. A.5), contained indicating lights showing when the relay contacts were closed. In addition, the rack operated a set of indicating lights on the television meter panel and controlled the starting of the raft radio-tone generator at − 15 sec. The relay contacts were interlocked with the firing signal.

Rack 6, the radio rack (wiring diagram shown in Fig. A.6), contained three vhf f-m radio receivers, three line-switching units, and a panel of auxiliary relays. The receivers were set to respond to different frequencies, and by the selection of the proper pairs of tones it was possible for each switching link to perform several different functions. The three links performed a total of 11 functions.

Rack 7, the zero rack (wiring diagram shown in Fig. A.7), contained arming and firing relays, safety switches, a 32-volt storage battery, undervoltage relay, inverters, emergency stop relay, and the clock arming circuit. Patch cables were used between the rack and the bomb.

Rack 8, the recorder rack (wiring diagram shown in Fig. A.8), contained eight Esterline-Angus recorders which ran continuously throughout the operation. Three of these recorders

[redacted]

[redacted]

monitored all signals on the radio-frequency channels, indicating what frequency the carrier was on and how long it was on this particular frequency. The other five recorders monitored the line-switching units, indicating when these units operated. It might be added that no spurious signals were ever received on any of the three radio frequencies.

2.3.2 Sequence Timer

Timing signals for Mike and King Shots were provided by an EG&G sequence timer, type 3158, shown in Fig. 2.3. This timer was designed primarily to meet the remote-operation requirements created by Mike Shot. Experience with the use of a type 3120 timer in previous operations enabled the incorporation of many desirable features and improvements in the latest design. Basically it consists of a main shaft mounting 18 cams which, when properly phased in sequence, engage cam arms to trip mercury switches and close signal circuits at the proper time. Nylon was used as a cam material in this timer to facilitate cam modification in the field without extensive machining. The increased number of cams available enables this type to be used for control of both air and ground shots by switching the electrical circuitry only. A clutch has been added to the drive system and has improved the total cycle accuracy by allowing the motor to reach its operation speed before the timing cycle commences.

Three timers were constructed and shipped to the atoll for use on this operation. One timer was installed in the timer rack on Flora for use on Mike Shot; one was installed in the CP on Elmer; and the third was used as a spare. Prior to installation, no attempt had been made to phase the cams into their proper sequence, although their relative positions on the shaft were made correct at time of assembly. The 30-min cycle (later changed to 15 min) of these cams caused the adjustment to be a somewhat lengthy procedure. When all adjustments were made, the individual cam repeatability was ±0.02 sec on slow times and ±0.01 sec on fast times. The timer performed satisfactorily on both shots, and present plans include its use on future operations of this nature.

2.3.3 Auxiliary Timer Stations

Operation Ivy utilized seven auxiliary timer stations to distribute signals to experimenters on the various islands of the atoll. Three of these stations contained special hold-in features; otherwise all were alike. The stations contained a power rack and one or two relay and signal-distribution racks, depending on the number of signals to be distributed. The three special stations, located on Edna, Irene, and Janet, were equipped with the d-c motor-driven cam timer discussed in Sec. 2.2.

Timing signals were sent from the master control station on Flora via submarine cables to the special stations on Edna and Janet and via underground cables to Irene. The Edna station fed all the required signals to Edna, Daisy, Clara, Belle, and Alice. The station on Irene fed all the signals required on Irene, Helen, and Janet. The Janet station controlled signals to Janet, Kate, and Mary and, in addition, fed relay signals to the station at Ursula. The station on Ursula, in turn, supplied all the signals required on Ursula, Sally, and Tilda and relayed signals to the timing station on Yvonne. The station on Yvonne controlled the signals required on Yvonne and also relayed signals to the Elmer station, which supplied signals to the experiment stations on Elmer.

2.3.4 Setup Procedures

On arrival in the Forward Area, the timing and firing group proceeded to the main control station located on Flora, where all personnel went to work on equipment installation. The first few weeks were spent solely on installation of television equipment and timing and firing equipment at this station. There were several reasons for this, the primary one being that it was deemed important to get the television system in working condition so that tests could be con-

[redacted]

[redacted]

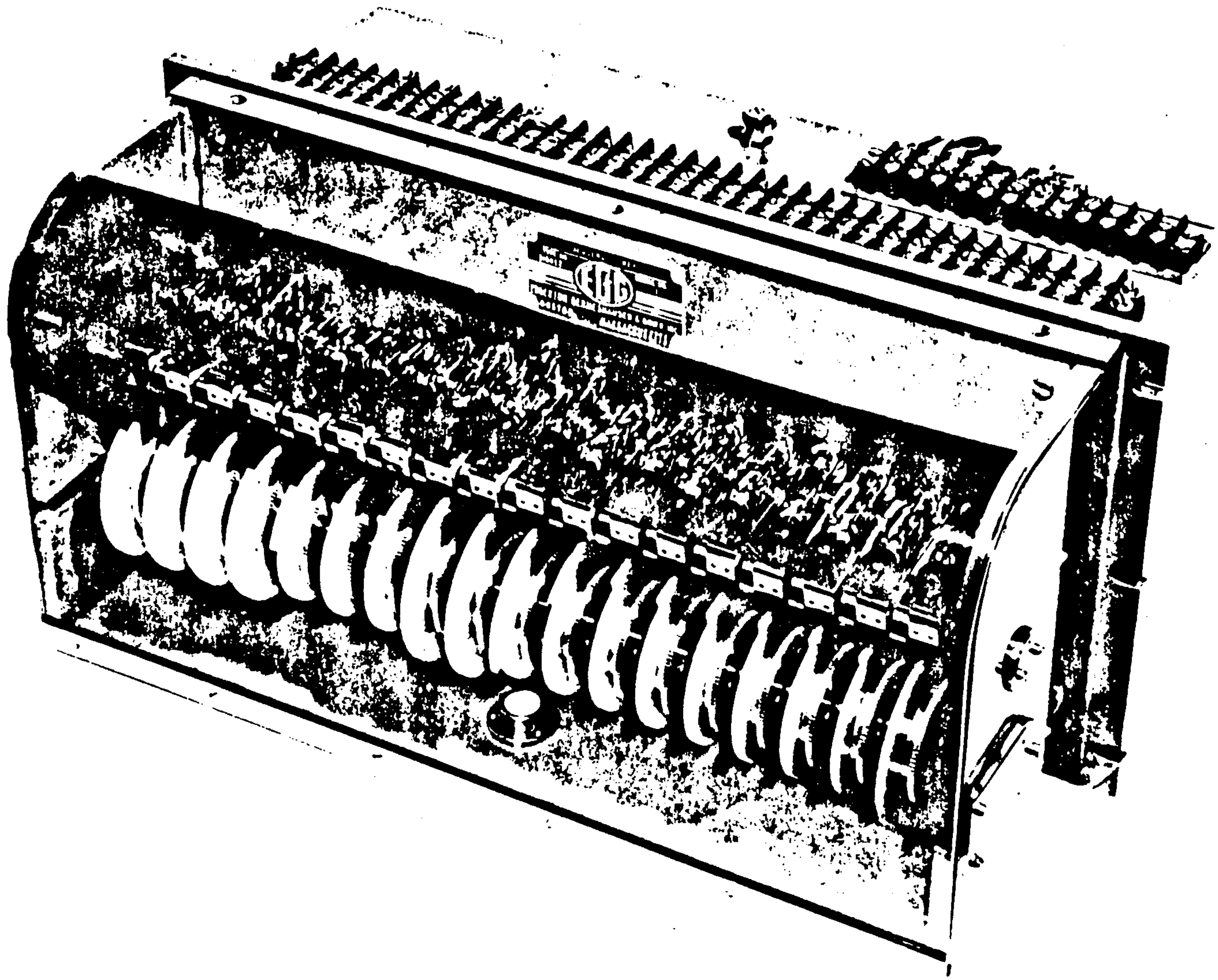


Fig. 2.3—Sequence timer, Type 3158.

[redacted]

ducted and adjustments could be made. Another reason was that the wires from the auxiliary stations to the experiment stations had not been laid at this time.

As work progressed on the main control station, work teams were dispatched to complete installations at the auxiliary station on Edna and to install relays on Daisy, Clara, Belle, and Alice. Since the number of signals required on these islands was small, it was possible to use the station at Edna to distribute signals to them via submarine cables. When installation on Edna was completed, dry runs began.

At this time work was concentrated on the auxiliary station on Irene and thence on Janet. When these were complete, work crews were dispatched to the stations on Ursula, Yvonne, and Elmer. Coincident with the Mike installations at the Elmer station was the equipment installation for King Shot at the CP. The signal-distribution rack at this station served as an auxiliary timer station for Mike Shot, after which it was readily converted into the King distribution system.

When work was completed on the upper-island installations, part of the group returned to Boston, and the remainder went to Elmer. The control station on Elmer was set up for an airdrop, as called for on King Shot. Signals were fed to the timing station on Yvonne via submarine cables, and, because the number of signals required beyond there was small, it was possible to feed the signals into submarine cables directly to the user, thus eliminating the auxiliary station on Ursula. King Shot required no signals north of Sally.

Dismantling of the Mike installations not usable on King was effected between Mike and King Shots, thus allowing all efforts to be devoted to King station dismantlement after K-day. After K-day the CP racks on Elmer were left set up in the station and will be available (with some modifications) for future operations. This station will be maintained in a continuously dehumidified condition to prevent corrosive action on the equipment.

2.3.5 U. S. S. *Estes*

The U. S. S. *Estes* housed the control room used on Mike Shot. This room contained the equipment for arming and firing the bomb, for receiving monitored information from the zero point, and for determination of zero world time. Some of this equipment was installed before the ship departed for the Forward Area, and the remainder was installed after the ship arrived at Eniwetok. The equipment and operation of the shipboard systems are discussed in detail under the appropriate headings in this report. It is sufficient to state that the equipment functioned properly. Power failure at about 40 min before zero time caused some anxiety before it was remedied and also caused some discrepancy in the world-time measurements.

2.4 FIRING PROCEDURE, MIKE SHOT

The procedure used in firing the bomb was as follows: The last dry run for timing and firing signals was held two days before shot day, at which time all switches were opened in the control station. This same day the firing party visited all the auxiliary timing stations, closing the switches to the signal-distribution stations which were to be operated at the time of the shot, closing the power switches, and finally locking each station. On M – 1 day the firing party went to the main control station on Flora and checked all the signal-distribution switches to make sure they were open. The radio signals were then sent from the control ship to the control station for testing purposes. The timer was started as though for a dry run and allowed to go through its cycle. The emergency stop signals were tried out, and, after the timer had completed its cycle, all switches were opened. The firing party then went to the zero station. About 5 hr before zero time the firing party connected the patch cables to the bomb. The firing party then returned to the control station and checked the firing lines for continuity. The connectors on the zero rack were checked to see that no voltage existed, and

[redacted]

the patch cords were connected to the zero rack. All the signal-distribution switches were closed, and finally the power switches were closed. Everyone was then evacuated from the island.

The firing party proceeded to the control ship and entered the control room where the meter panel was being monitored on the television screen. At −1 hr the time-clock arming switch closed and indicated that the bomb could be fired. This closure was indicated on the television panel when the arming switch went from the off to the on position. At −30 min a control switch was closed, and a 30-min radio signal was transmitted. The 30-min indicating light on the television panel changed from the off to the on position. At −15 min the sequence starter switch was closed, and the cam timer started to run. An indicator light on the television panel showed that the 15-min signal had been operated, and a blinking light indicated that the cam timer was running. The sequence timer began the automatic sequence, with the cam closing the signal switches at −5 min, −30, −15, −5, $-1\frac{1}{2}$, and −1 sec, and zero.[1] As each signal went on, an indicating light changed on the television panel to show that the relay had operated. At zero time the bomb fired and the television screen went blank, indicating that the station was destroyed by the explosion. At +1 sec, the +1-sec signal was provided by the auxiliary station hold-in circuits.

2.5 KING SHOT

2.5.1 Basic Timing System

King Shot was a scheduled airdrop, and the timing system was set up similar to that used on the Buster-Jangle[2] and Tumbler-Snapper[3] airdrops. The cam timer used for King Shot was similar to that used for Mike Shot except that the total cycle was 60 sec. The timer was started by a radio tone in the strike aircraft, controlled by the dropping of the bomb. The radio tone held open a relay; at the release of the bomb the tone ceased, causing the relay contacts to close, thereby starting the timer. The timer cams were adjusted so that zero time occurred 46.2 sec after the release of the bomb, this time being the predicted time of fall of the bomb. The cam timer provided an automatic sequence of signals at −30, −15, −5, $-2\frac{1}{2}$, $-1\frac{1}{2}$, and $-\frac{1}{2}$ sec. There were three manual signals given before the bomb was dropped, these being at −30, −15, and −5 min. The operation of these signals was based on the assumption that the bomb would be released at a certain specified time. However, the bomb-release time differed by several seconds from the predicted time so that these signals had an error in them equal to the difference between the predicted drop time and the actual drop time.

2.5.2 Apparatus and Procedures

The King CP on Elmer served as an auxiliary timer station on the Mike Shot and was readily converted to act as the King control station after Mike Shot. This conversion was accomplished by simply connecting the signal lines from the signal-distribution rack to the King sequence timer rack. Much of the equipment in this station was installed before the Mike evacuation; the final installations were completed shortly after reentry to the island.

Dry runs were carried out before K-day in the same way as they were before Mike Shot. The numerous postponements of K-day necessitated additional dry runs in order to make sure that all signals were being sent before each scheduled K-day.

Figure 2.4 is a photograph of the interior of the CP, showing the arrangement of racks. The racks include the power rack, timer rack, test rack, signal-distribution rack, and the world-time rack. These racks are identical to those described for Mike Shot in Sec. 2.3.1. The timer rack differed somewhat in that the cam timer was set up to operate at the cessation of a radio tone and to provide a different sequence of signals.

[redacted]

[redacted]

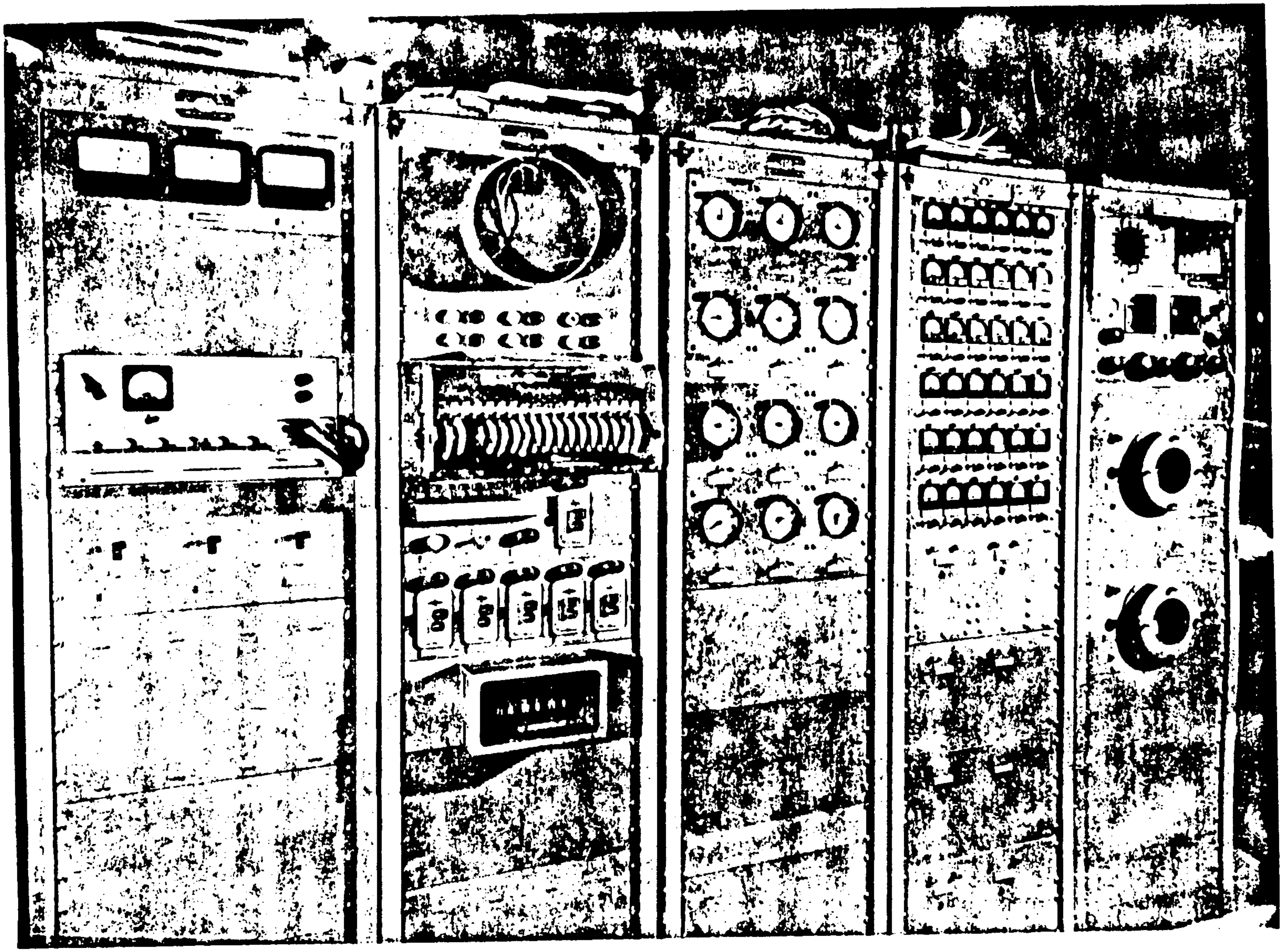


Fig. 2.4—Interior of the Elmer Control Point. The racks shown are, from left to right: power, timer, test, signal distribution, and world time.

[redacted]

[redacted]

2.6 WORLD-TIME DETERMINATION

The world-time rack was installed in the control room aboard the U. S. S. *Estes* for Mike Shot (see Fig. 2.5) and in the CP on Elmer for King Shot. The rack was equipped with a sensitive short-wave receiver for picking up time signals from station WWVH and also contained two clock panels (one indicating the hour, minute, and second and the other indicating hundredths of a second) and two recording cameras. At the instant of burst a Blue Box closed the firing relay, and the two cameras automatically took a picture of the clock faces. In order to calibrate these clocks, a picture of the clock face was taken several minutes before zero time and several minutes after zero time, and corrections were determined from WWVH time signals. Photographs of the clock faces taken on Mike Shot appear in Fig. 2.6, and the calibration figures and true world time appear in Table 2.1. World-time determination on King Shot was unsuccessful because the Blue Box did not trigger. A manually operated stopwatch shows the burst to have occurred within 2 sec of the target time. Mike Shot determination involved a discrepancy of ±0.2 sec due to power failure at about 40 min before zero.

Table 2.1—IVY WORLD TIMES; ENIWETOK LOCAL TIME SHOWN

	Mike Shot, Nov. 1, 1952 0715*	King Shot, Nov. 16, 1952 1130*
	Slow-clock Readings	
At shot time	0714:53.8	†
At calibration	0734:54.4	
WWV signal	0735:00.0	
∴ correction	+:05.6	
Shot "time"	0714:59.4	
	Fast-clock Readings	
At shot time	:48.015	
At calibration	:48.790	
WWV reference	:00.000	
∴ correction	+:11.210	
Shot + correction	:59.225	
	World Time Corrected	
	0714:59.225‡	

*Target time.

†No data due to the failure of the Blue Box to trigger. However, a manually operated stopwatch shows the burst to have occurred within 2 sec of the target time.

‡Power failure at −40 min resulted in unstable operation of the frequency-controlled power and discredits the world-time readings by a factor of ±0.2 sec.

[redacted]

[redacted]

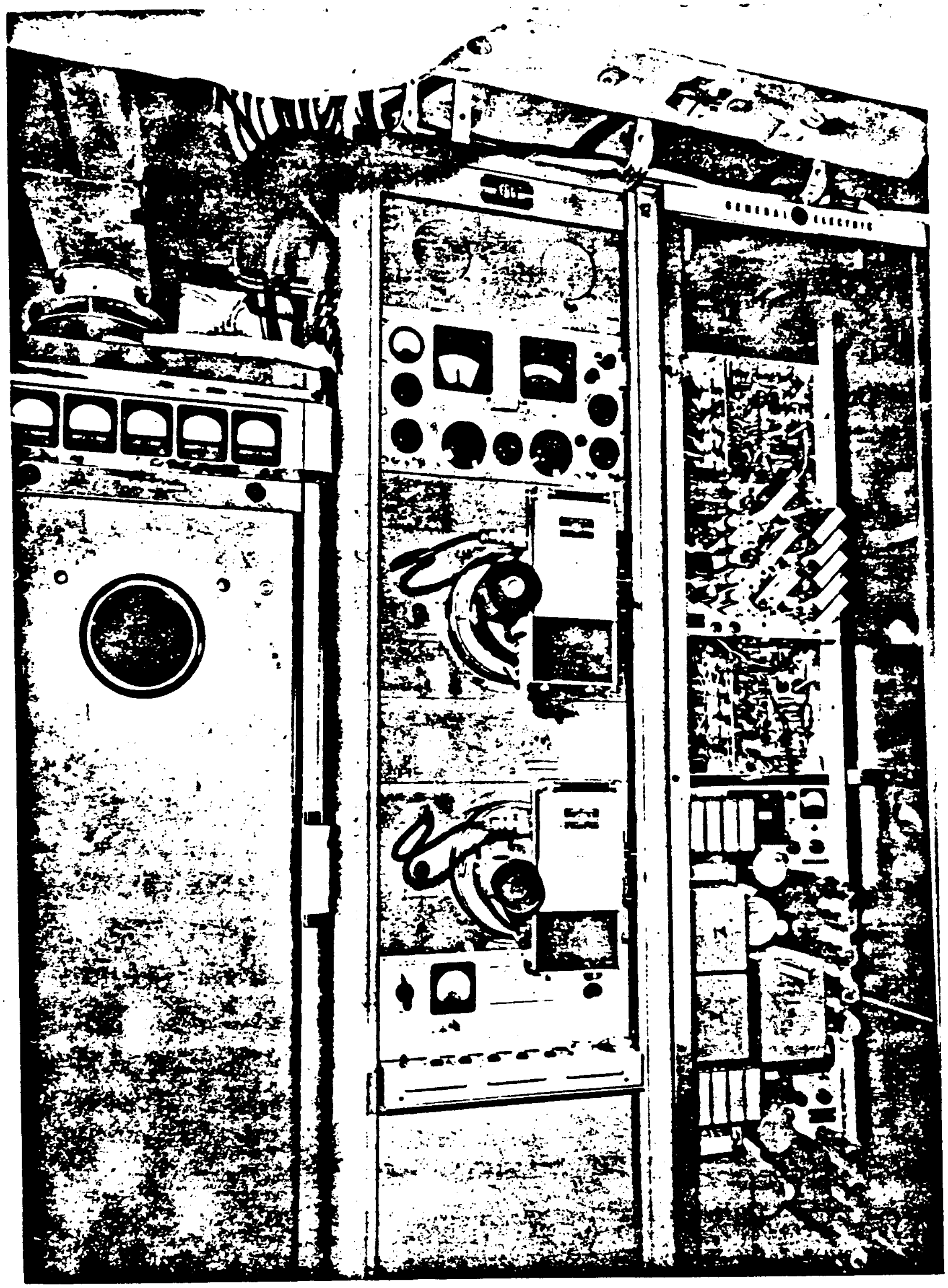


Fig. 2.5—World-time rack in the control room on the U.S.S. *Estes*.

[redacted]

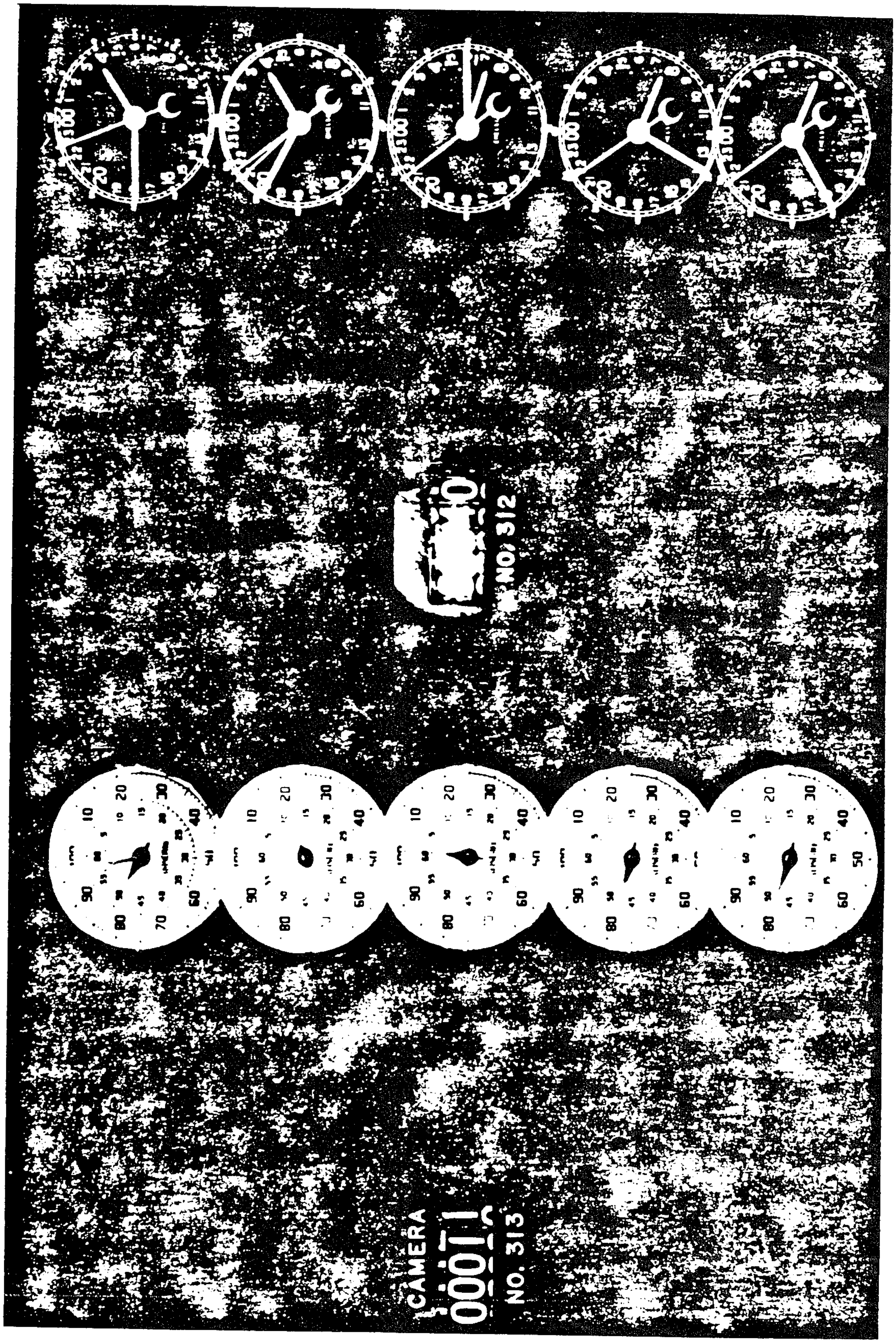


Fig. 2.8—World-time clocks for Mike Shot.

[redacted]

2.7 CONCLUSIONS AND RECOMMENDATIONS

Many of the problems encountered on Greenhouse were again met on Ivy. Since the job necessitated sending work parties to various islands, the very real problem of communication was involved. Use of walkie-talkies and Motorola two-way radios greatly improved this situation over previous operations. At times, however, the channel became crowded, with the result that work between groups was halted while waiting for the channel to be cleared. The use of telephone hand sets for wire checking would do much to improve this situation and cut down the use of the radio channel.

The use of a well-equipped truck such as the type used by public-utility companies has been proposed for the timing and firing group. Much time was lost by work parties having to return to their supply base for materials which were needed but which had not been considered necessary until the parties reached the work island. Boat-transportation difficulties made these return trips tiresome and time-consuming. Such trucks would also offer superior protection from the elements to both personnel and equipment.

While work was being concentrated on the control station on Flora, Holmes and Narver (H&N) was being pushed to install and terminate signal cables to users on the shot island and adjacent islands. However, this work did not progress so rapidly as that of the timing group, and therefore the timing group was soon in a position where they had to do the termination themselves in order to continue their work. They terminated all signal lines on Alice, Belle, Clara, Edna, Gene, Helen, Irene, Janet, Kate, Ursula, and Yvonne. Since no spare signal cables were installed, it was necessary to make return trips to several islands when it was discovered that some lines were defective and had to be restrung. It is estimated that a week's time was lost by the relay crew as a result of the additional workload caused by unterminated lines, defective cable, unlabeled lines, and wire stringing.

In the future, installation and termination of cables should be finished well enough in advance so that the timing and firing group could concentrate solely on their work. Also, it would be practical for H&N to install spare signal cables which could be utilized in the event that defective cables were encountered. The additional cost of spare cables would more than be justified in time gained later on.

The breaking and tearing up of signal cables by bulldozers and other vehicles was still a problem, but the number of cases was considerably less than on previous operations mainly because steps were taken to prevent this trouble. These steps require the close cooperation of the vehicle operators in respecting the cable markers and signs.

The radio system was invaluable in providing direct and rapid communication between working parties.

REFERENCES

1. J-11680, Ivy Instrumentation Chart.
2. Buster-Jangle Report, Timing and Firing, WT-419.
3. Tumbler-Snapper Report, Timing and Firing, WT-561.

[redacted]

[redacted]

CHAPTER 3

TELEVISION MICROWAVE LINK

3.1 BACKGROUND

Because of the nature and size of Mike Shot, it was essential that a number of conditions at the zero point be indicated at the CP. Since the location of this CP was aboard a ship at sea, the use of submarine cable became impractical. A normal radio telemeter system could have been used, but the number of channels necessary, using either a frequency-basis or a time-basis multiplex system, would have made a complicated arrangement. Either system would have required conversion of the required information to signals acceptable to the telemeter and then reconversion of the signals back to interpretable information at the receiver point.

A commercial television system offers several advantages when used as the telemeter link. The most obvious advantage is that the desired information may be taken directly from a number of different indicating instruments without individual conversion to electrical signals. This advantage carries through to the receiver site in that no reconversion is necessary in order to obtain an identical set of information.

Figure 3.1, a photograph of the control monitor for channel 4, indicates the clear, accurate, and readable quality of the monitored information. It shows the meter board with its complement of cryogenics groups dials and lights, indicating what timing signals are in. Note that the 30-, 15-, 5-, and 1-min signals are in at this time. Repeaters require no special consideration with respect to calibration. The received indications of the various conditions are independent of the condition of the telemeter system. In addition, an important advantage is that most of the television equipment is produced in relatively large quantities and is usable, for the most part, without modification. Generally speaking, a television system offers the most flexible, and perhaps the most reliable, telemetering system available, although admittedly it is not the most economical to install.

3.2 INSTRUMENTATION

For reliability of operation, two complete separate television systems, consisting of commercial television broadcasting equipment, were used. The block diagram of the transmitting chain is shown in Fig. 3.2. Each channel had a synchronizing signal generator (which fed signals to a drive rack containing power supplies), a blank and shade generator, a camera sweep generator, and a video channel amplifier. The drive rack fed the necessary power and driving signals through a 50-ft cable to an iconoscope camera. The picture signal produced in the camera was carried back through a coaxial conductor in the 50-ft cable to the video channel amplifier in the drive rack. The output of this amplifier, which contained video and blanking signals but no synchronizing signal, was fed to a utility amplifier group, together with

[redacted]

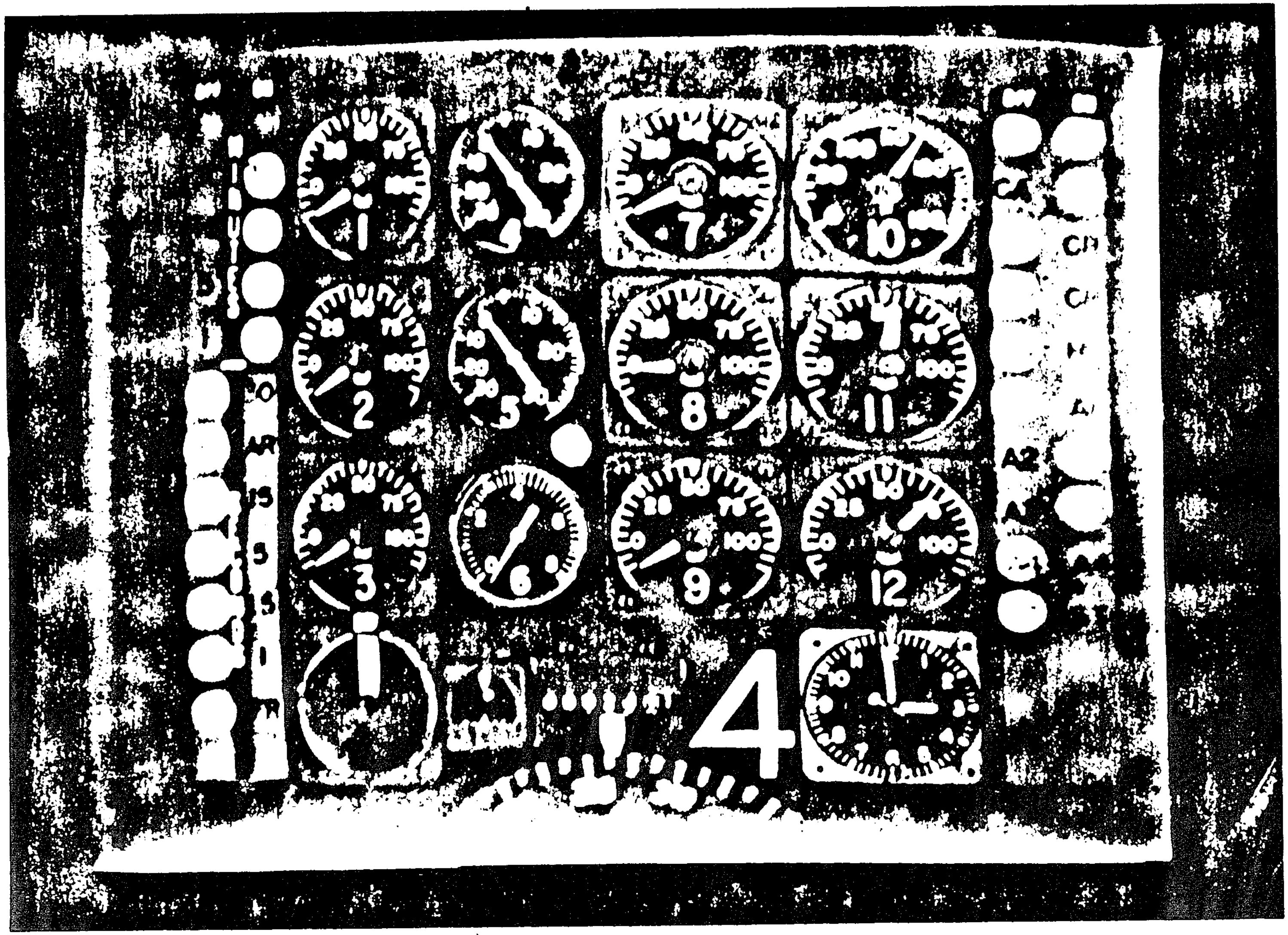


Fig. 3.1—Photograph of the mosaic on the front of the control monitor of channel 4. The monitor was located in the control room of the U.S.S. *Estes* which was anchored in the lagoon at the time this picture was taken.

[redacted]

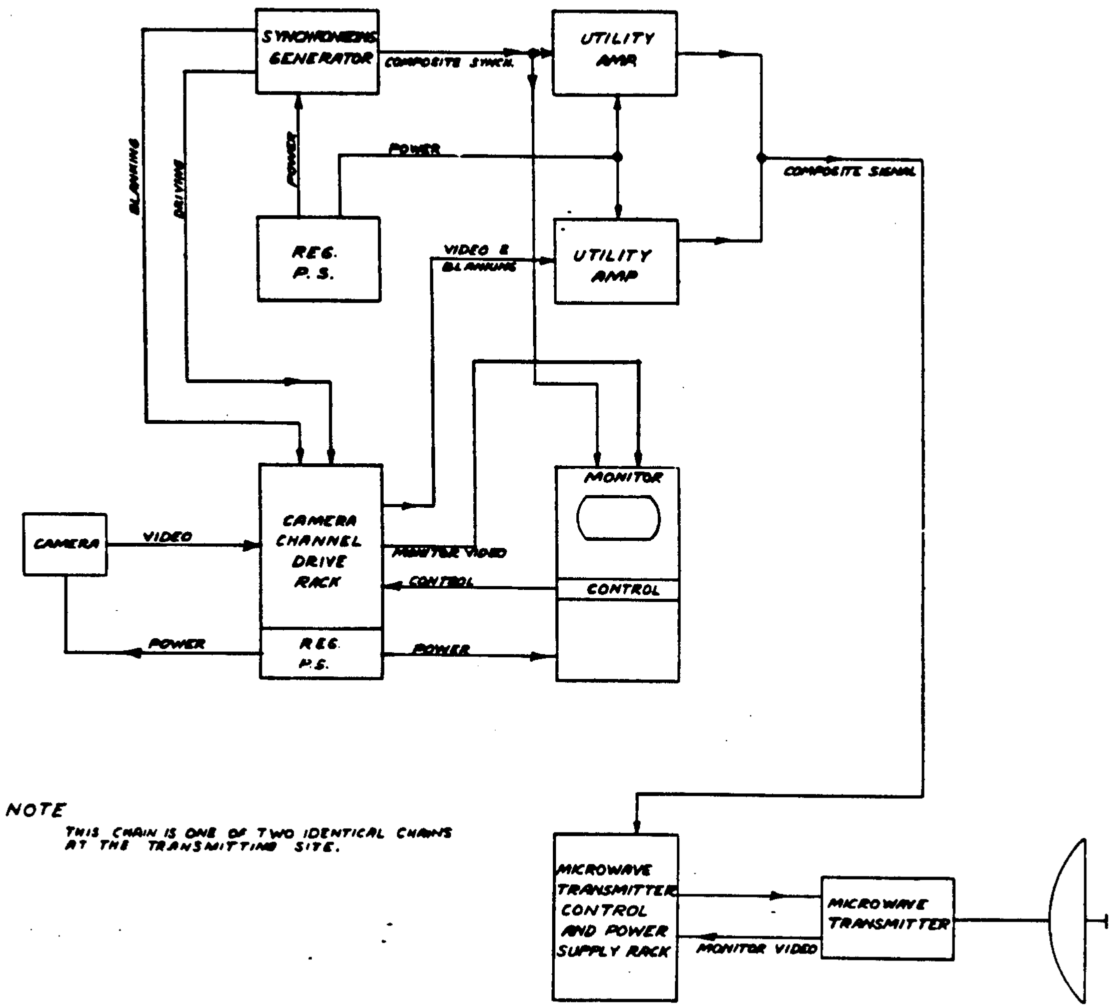


Fig. 3.2—Block diagram of transmitting chain.

[redacted]

[redacted]

synchronizing signals from the synchronizing signal generator. Mixing was performed in this amplifier group, resulting in a standard television signal. This signal was fed to a microwave-transmitter control rack and, ultimately, up to a 2000-Mc microwave transmitter located on the top of a 375-ft tower (see Figs. 3.3 and 3.4). A monitor was provided to view the image sent to the microwave transmitter.

The camera was the only item of equipment in the transmitting chain that was not a commercial standard. An iconoscope camera normally used to transmit motion pictures and slides was modified by the addition of a lens system so that it could be used in the same manner as the usual image orthicon camera. The major reason for this change was to obtain the greater life and reliability of the iconoscope. The image orthicon has a somewhat unpredictable life, losing sensitivity after several hundred hours of life. In addition, an image orthicon operating below its normal temperature may have a pattern burned in that will remain for minutes after the scene viewed by the camera has changed. Also, the resolution capability of the image orthicon, until recently, has been lower than that of the iconoscope. Compensation for the low sensitivity of the iconoscope was made by increasing the light level on the meter board to be televised.

The receiving system (the block diagram is shown in Fig. 3.5) consisted of the microwave receivers for the two channels, distribution amplifiers for isolation of the video coaxial transmission lines, regulated power supplies, train control, and the various picture monitors (see Figs. 3.6 to 3.8). The only unusual features of this system were due to the location aboard ship. The parabolic reflectors for the receiving antennas were mounted on a modified radar antenna pedestal. This unit automatically corrected the antenna direction to compensate for changes in the ship's heading as well as to correct for pitch and roll of the ship. The physical location of the receivers made necessary the use of pressurized rigid coaxial transmission lines from the antennas to the receivers to keep attenuation low. Flexible sections of coaxial cable consisting of RG-17/U cable were used rather than rotating joints in the antenna pedestal to avoid the possibility of introducing unnecessary discontinuities and additional attenuation in the transmission line.

A permanent record of the meter image on the television screens before and up to the zero time was obtained by the use of two Cine Special motion-picture cameras mounted on fixed pedestals in front of the screen.

One of the features of the system worthy of mention is the vertical spacing of the transmitting antennas by a distance of 50 ft to obtain some difference in the transmission path between transmitter and receiver site. The lower antenna was placed at a height giving sufficient clearance of the microwave transmission path above the water for the desired path length, according to normal uhf techniques.

It was also found necessary to control the transmitting-antenna direction by radio, since the transmitting station had to be operated unattended. The narrow beam width of the transmitting antennas made changes in their direction necessary as the ship maneuvered.

3.3 PREPARATION AND SETUP PROCEDURE

A series of tests were conducted on the television equipment in Boston to determine the necessary modifications to the camera and the characteristics of the meter on the televised panel, as well as to test the microwave relay link operation over water.

The insertion of a lens system into the camera placed an inverted image on the mosaic of the iconoscope tube in the camera. The most straightforward method of resolving this difficulty in the case of this particular camera design was to turn the camera over and rework the camera case to conform. It was found desirable to incorporate a large lens in the new setup. An f/2.7 lens with a $6\frac{1}{2}$-in. focal length producing a 4- by 5-in. image proved to be satisfactory. A bellows was found necessary in order to limit extraneous light, but the case did not need to be completely lightproof as in photographic cameras.

[redacted]

[redacted]

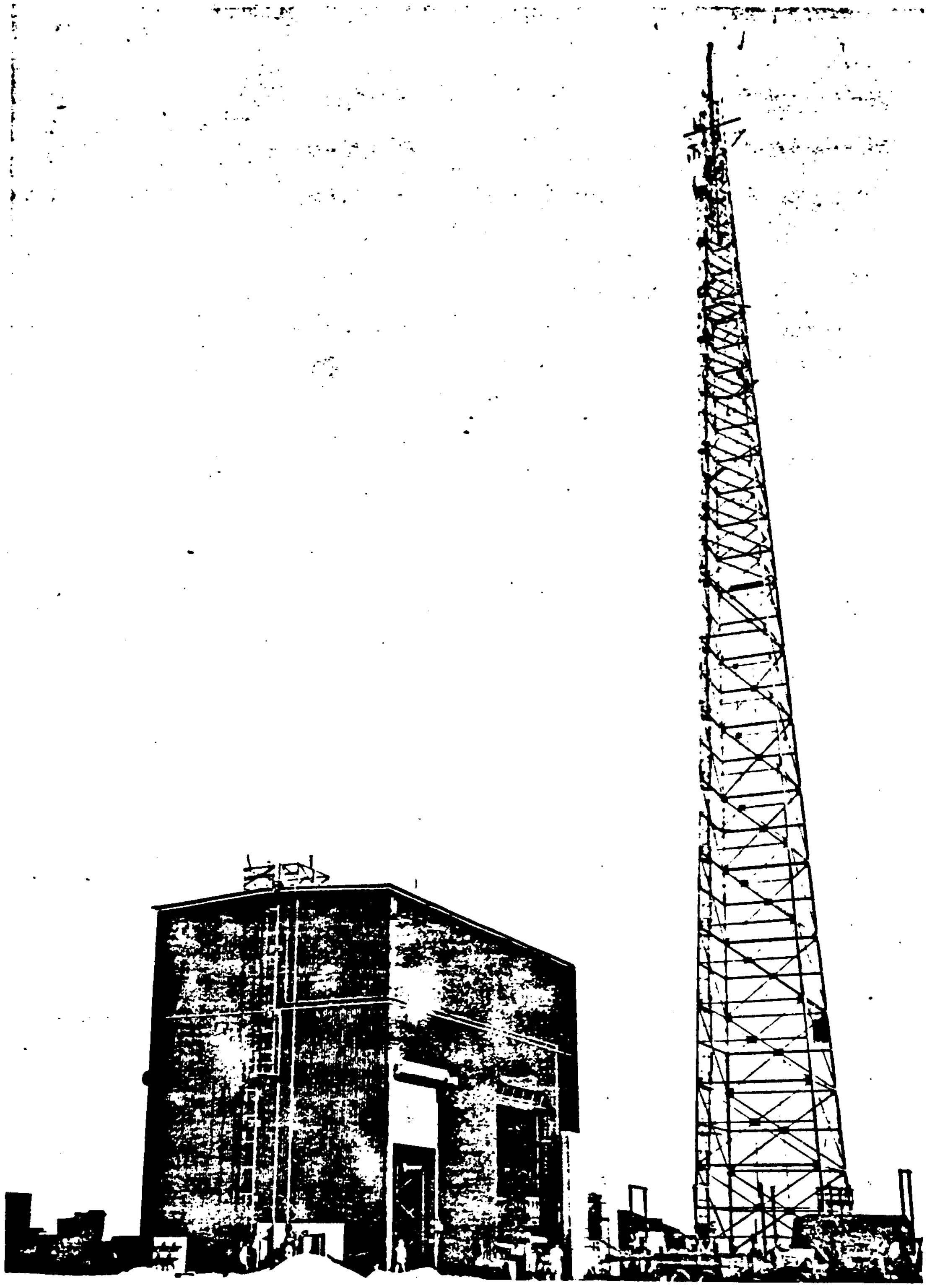


Fig. 3.3—View of the 375-ft microwave transmitting tower at site zero during its last days of construction.

[redacted]

[redacted]

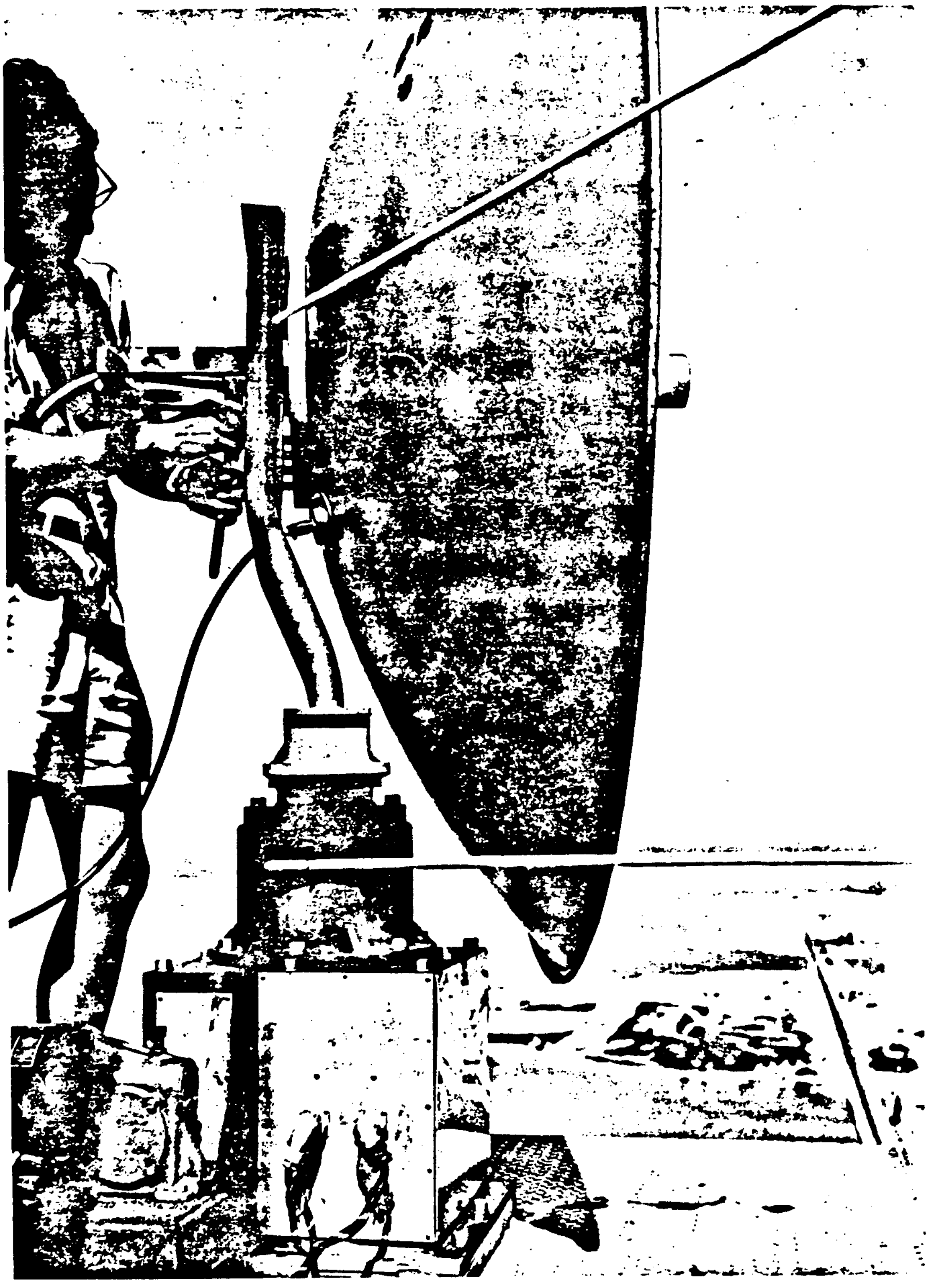


Fig. 3.4—View of the 2000-Mc microwave transmitter on top of the 375-ft tower at site zero on Flora.

[redacted]

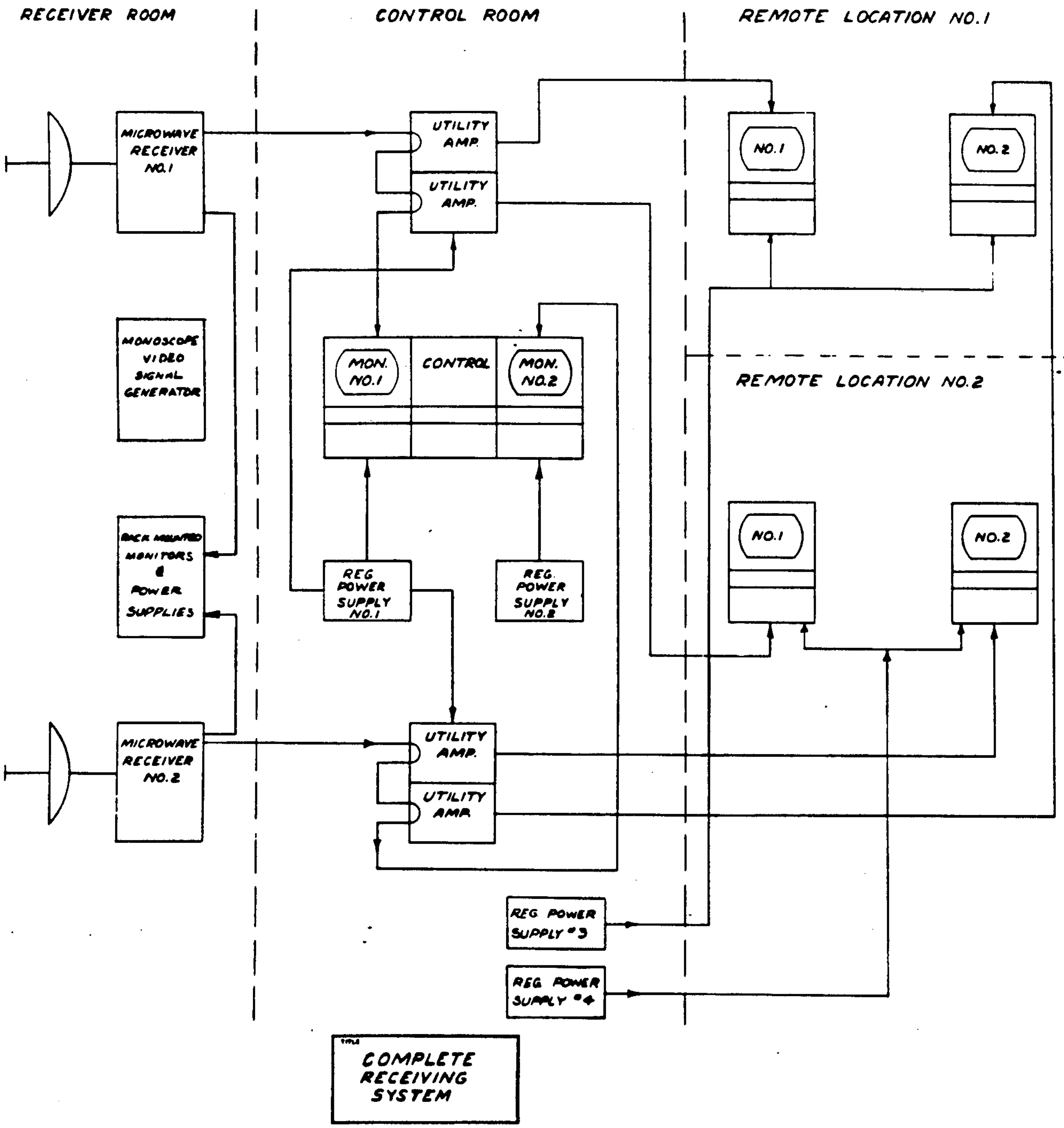


Fig. 3.5—Block diagram of receiving system.

[redacted]

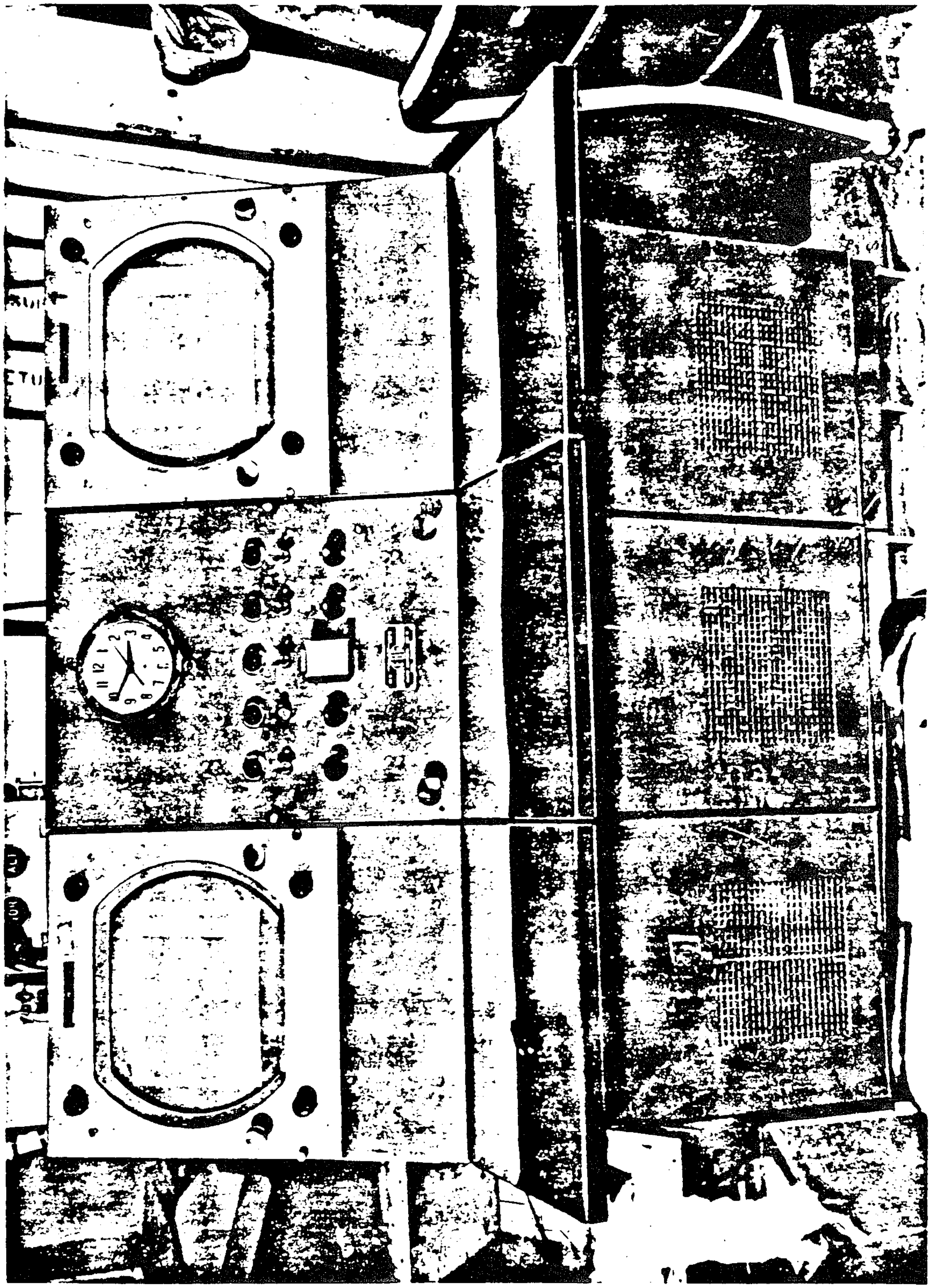


Fig. 3.6—View of the control console on the U.S.S. *Estes* showing both channels in operation.

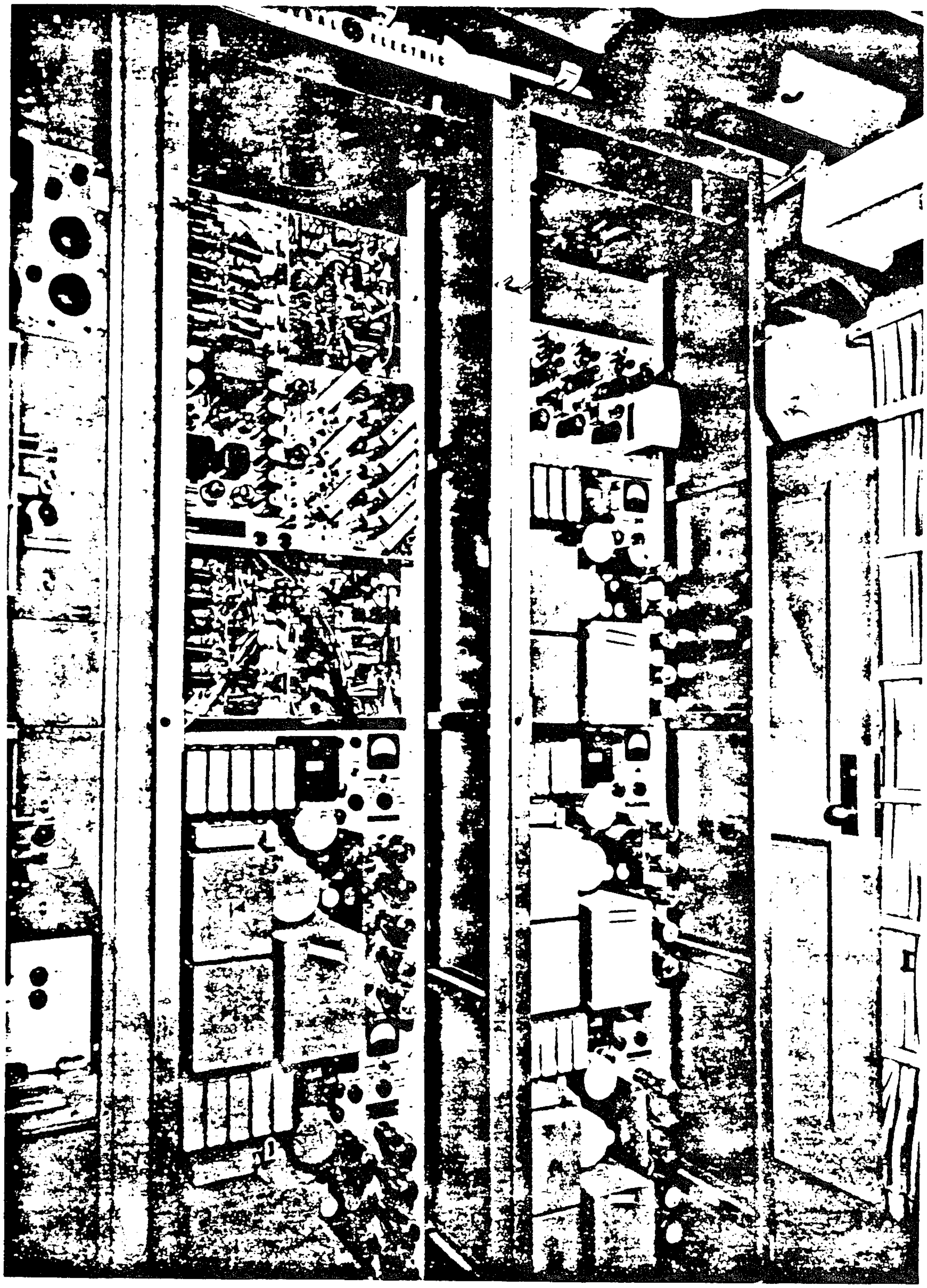


Fig. 3.7—Radio-tone generator and television-power-supply racks in the control room on the U.S.S. *Estes*.

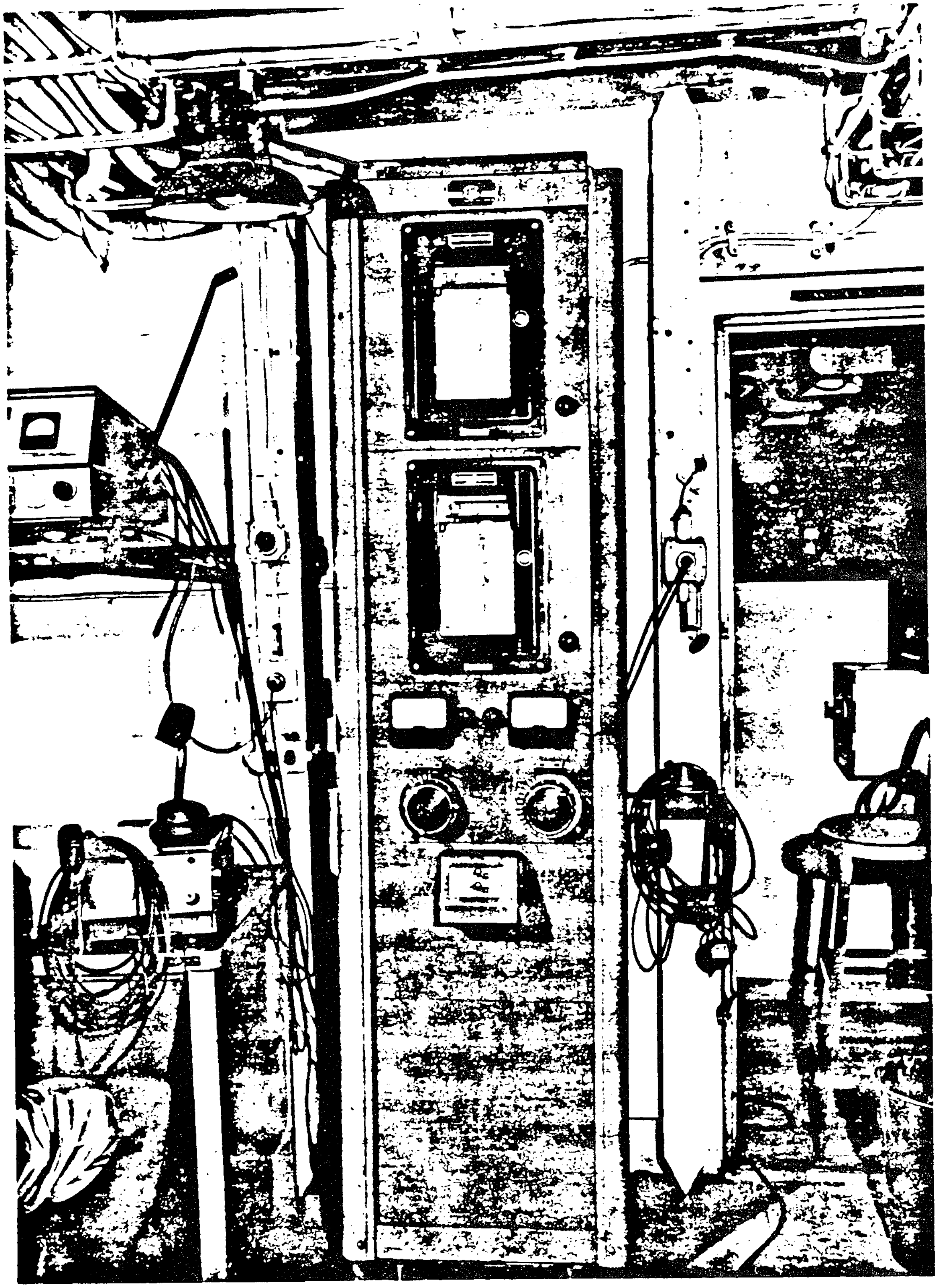


Fig. 3.8—Train control rack in the control room on the U.S.S. *Estes*.

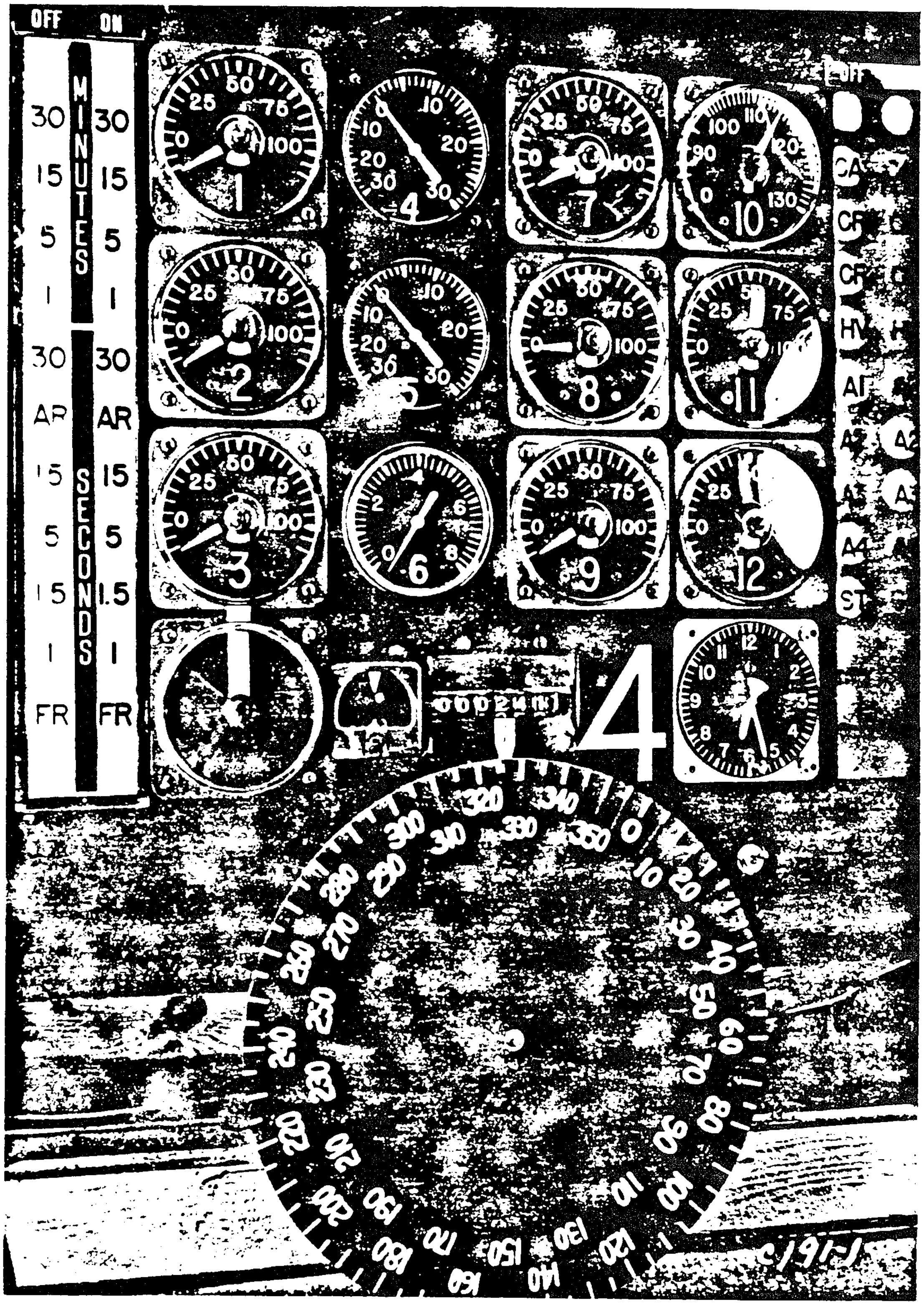


Fig. 3.9—Meter board used to indicate the desired information at the zero station. This board is shown in Fig. 3.1 as it appears on the television screen on the U.S.S. *Estes*.

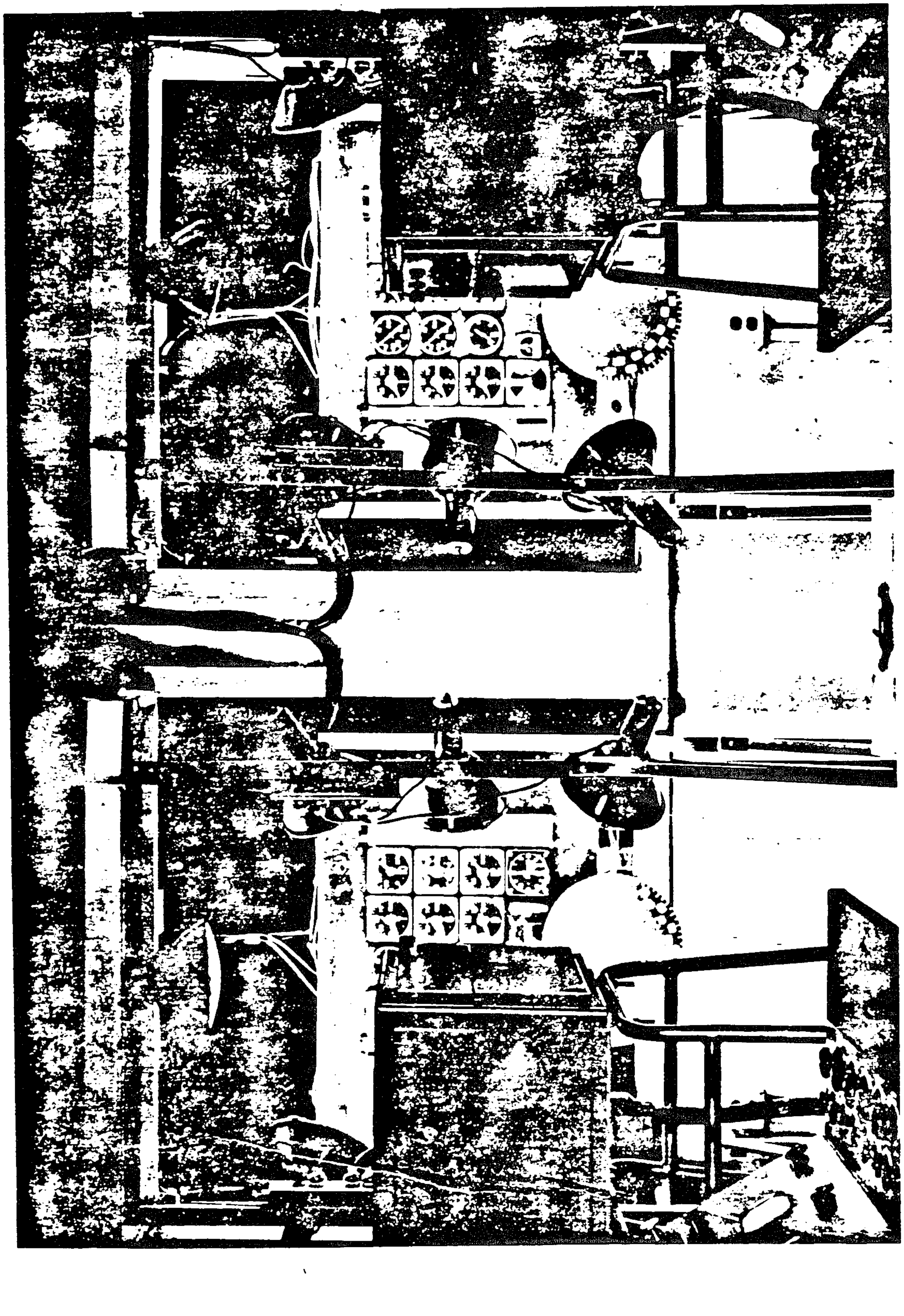


Fig. 3.10—View of the two-channel transmitting equipment showing the meter board, lighting, cameras, and check monitors.

[redacted]

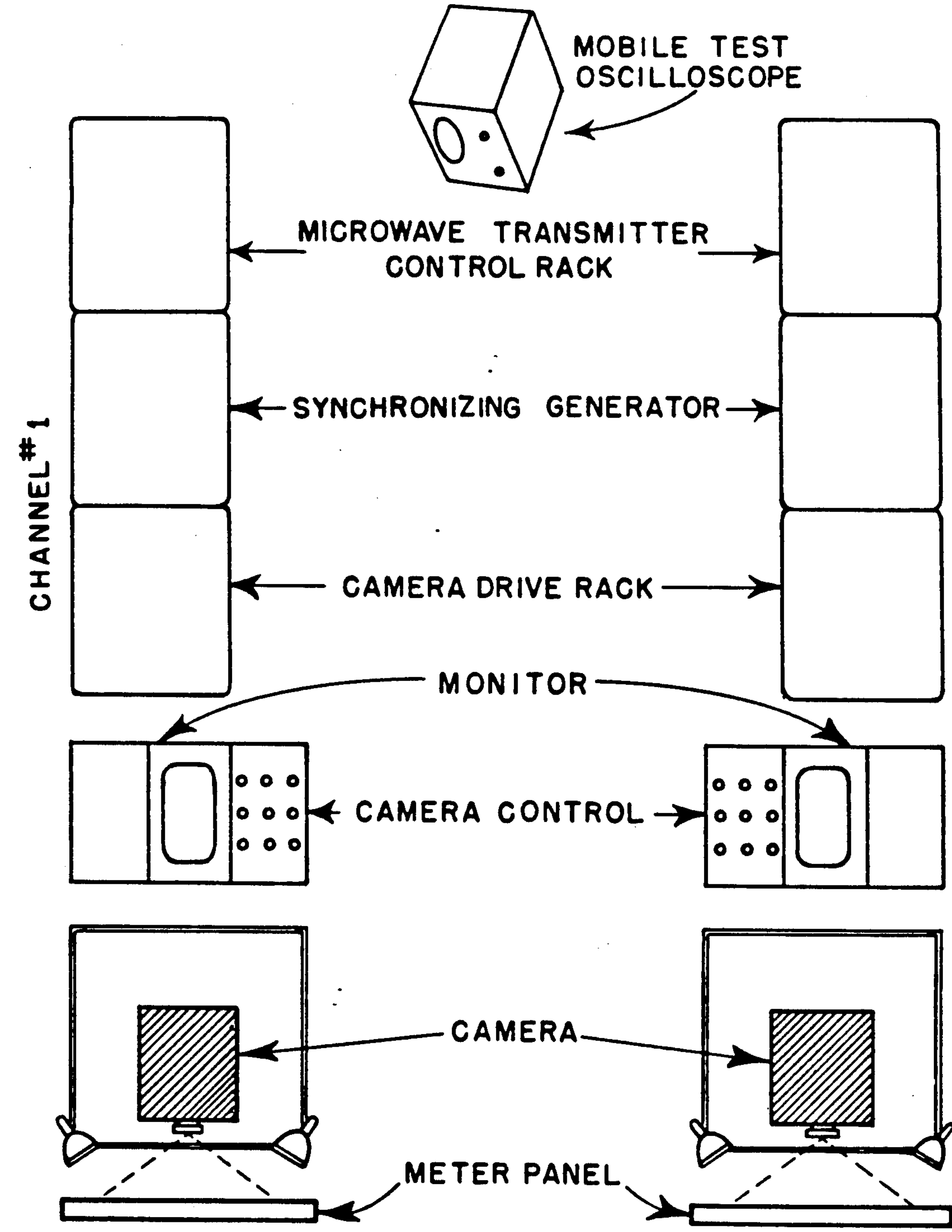


Fig. 3.11—Floor plan of the television equipment at site zero on Flora.

[redacted]

The meters used in the panel were General Electric DB-18 movements. The white face with black figures was replaced by black laminated bakelite so that the figures could be depicted in white. Figure 3.9 is a front view of this panel showing these features. An optimum size for the figures was established which would best be fixed by the angle subtended at the camera. Roughly speaking, the object distance was 4 in., using the lens mentioned. The field of view was about 30 by 40 in., although the meters covered a rectangular area of about 27 by 36 in. The numbers under these conditions were $\frac{3}{8}$ in. high and were satisfactorily readable on the receiver monitors. The width of lines for divisions were about 0.06 in. A satisfactory method of placing pilot lights on the meter panel consisted in using standard 6-watt pilot-light holders covered with frosted glass. Identification was obtained by painting black figures on the glass in front of each individual pilot light.

The whole meter panel was black in order to cut down extraneous light reflections into the camera and was mounted on a framework to which the camera and supports for the lights were also attached. For a picture of this arrangement, see Fig. 3.10. Seven 200-watt floodlights were used and were placed three on each side of the meter panel and one above it at a distance back from the panel of about 2 ft and just outside the field of view of the camera. It was found that, by placing a blue-green transmission filter on the camera, the resolution of the system was increased. This is the color of maximum sensitivity of the iconoscope.

The two microwave systems were set up in Boston to transmit on an over-water path of about 25 miles, with antenna heights duplicating as nearly as possible those expected. After initial contact was established, the system was operated for a period of about three weeks, including several tests of more than 24 hr. Both horizontal and vertical polarization were tried. The relative field-strength records showed vertical polarization to be somewhat less susceptible to fade conditions, although horizontal polarization produced received-signal strengths a little stronger, generally, than vertical polarization.

The initial setting up of equipment in Boston required the making up of coaxial cables of various lengths. These cables were labeled on both ends with regard to their use and shipped with the equipment. As a result, this time-consuming work was almost completely avoided in the field. The final arrangement of the transmitting equipment in the zero station is shown in Fig. 3.11. This arrangement fulfills one of the basic requirements of the system as far as layout is concerned; i.e., access to both front and back of the racks with the test oscilloscope was readily accomplished.

3.4 OPERATION AND RECOMMENDATIONS

As a whole, the equipment operated satisfactorily. Television certainly provides the most flexible solution to the telemetering problem. Certain changes might be made in the equipment on a future operation, but most of these are minor and would serve merely to increase convenience of operation. One weak point of the system appears to be the receiving antenna, transmission line, and mixer stage of the microwave receiver. It is understood that the receiver is being redesigned by the manufacturer. Details of this redesign are not available, but it is believed that the mixer, local oscillator, and one or two i-f stages ought to be built as a remotely controlled unit so that they could be placed directly at the antenna position.

Receiver controls, including antenna train control and receiver tuning, should be located together at a point where a monitor can be seen.

[redacted]

CHAPTER 4

RADIO-TONE SIGNALS

4.1 RAFT RADIO-TONE SYSTEM

4.1.1 Equipment

The mortar raft system used on Mike and King Shots was designed to provide smoke puffs at various predetermined points over the lagoon for the observation of shock-wave phenomena. Rafts were anchored in the lagoon and equipped with smoke mortars and radio receiving equipment for firing the mortars from a remote point. Figure 4.1 shows the positions of the raft radios in the lagoon.

The system was primarily a vhf (152.93-Mc) f-m link, with a radio transmitter sending a trigger signal to receivers on the rafts. The receivers started timers which picked up this trigger signal and fired the mortars at various times, depending on the distances of the particular raft from zero. The timers were necessary in order to produce smoke puffs just prior to the arrival of the shock wave, thus providing insurance against smoke-puff dispersion by air currents before the shock wave arrived.

The trigger signal was modulated with a tone code consisting of two pairs of audio tones sent in sequence. Tone-code selectors in the raft-receiver output circuits permitted only the proper tone code to trigger the system.

Ten-day wind-up clocks were used to automatically turn on the raft receivers prior to transmission of the trigger signal.

All pieces of equipment on the rafts, excepting the mortars, were mounted in watertight boxes.

4.1.2 Transmitter Setup

The equipment at site zero on Flora consisted of a Motorola tone generator and a Motorola radio transmitter. A 30-watt transmitter was used for Mike Shot, and a 10-watt transmitter was used for King Shot.

The tone generator was of the type used in commercial radio networks for selective calling of stations. The audio tone code, which can be selected by the operator by means of push buttons, is used to open up the desired receiver on the network for communication. Other receivers will not hear the conversation even though they are on the same radio frequency.

In the raft radio setup this tone code was used to provide protection against spurious firing of mortars. Only one code was used on this operation, and thus it was possible to wire in the code selection. The proper code was automatically sent whenever the system was keyed.

The system was keyed from the sequence timer at H−15 sec. Figure 4.2 is a schematic diagram of the transmitting system.

The raft receivers were of the 6-volt mobile type manufactured by Motorola. The

[redacted]

[redacted]

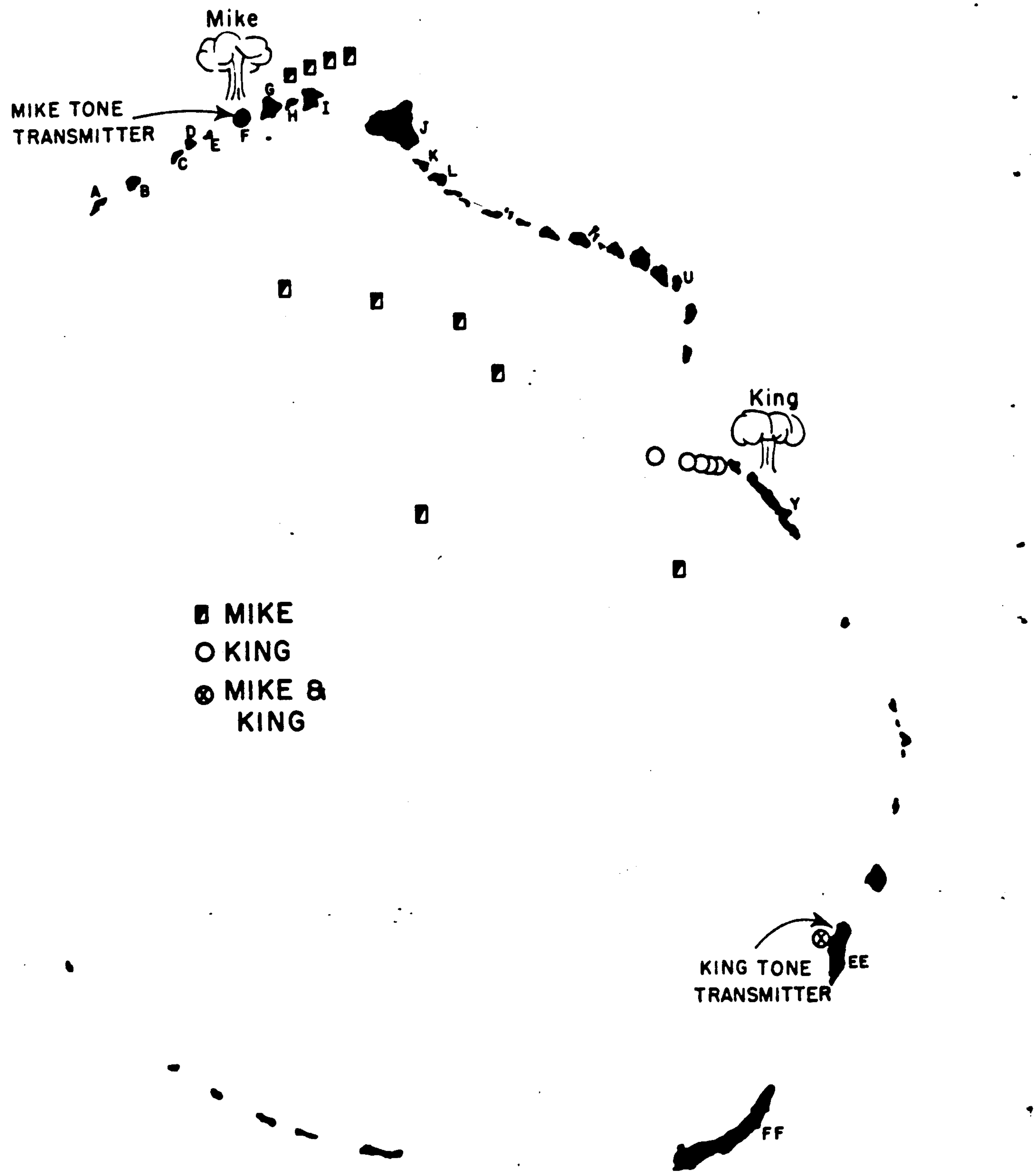


Fig. 4.1—Mortar-Jato raft stations used on Ivy, showing positions of rafts on Mike and King Shots.

[redacted]

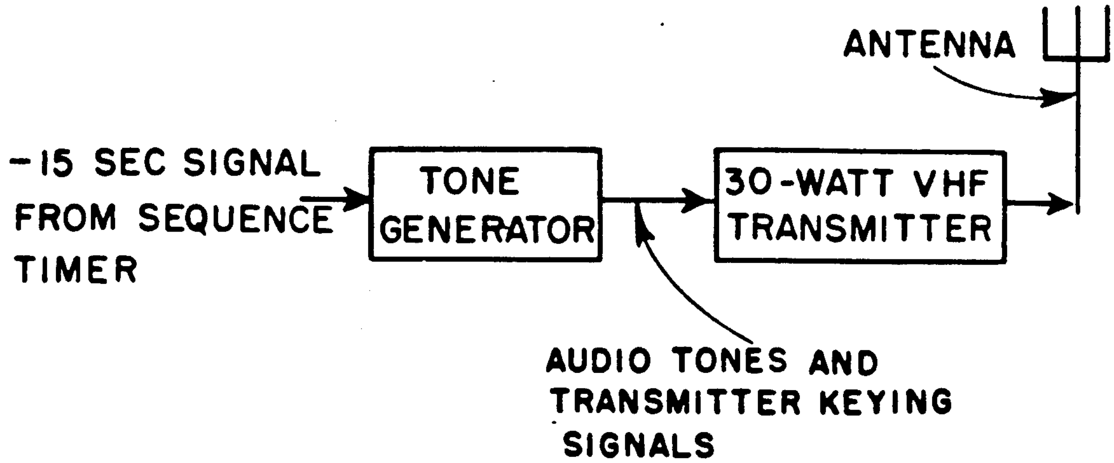


Fig. 4.2—Schematic diagram of the raft radio transmitting system.

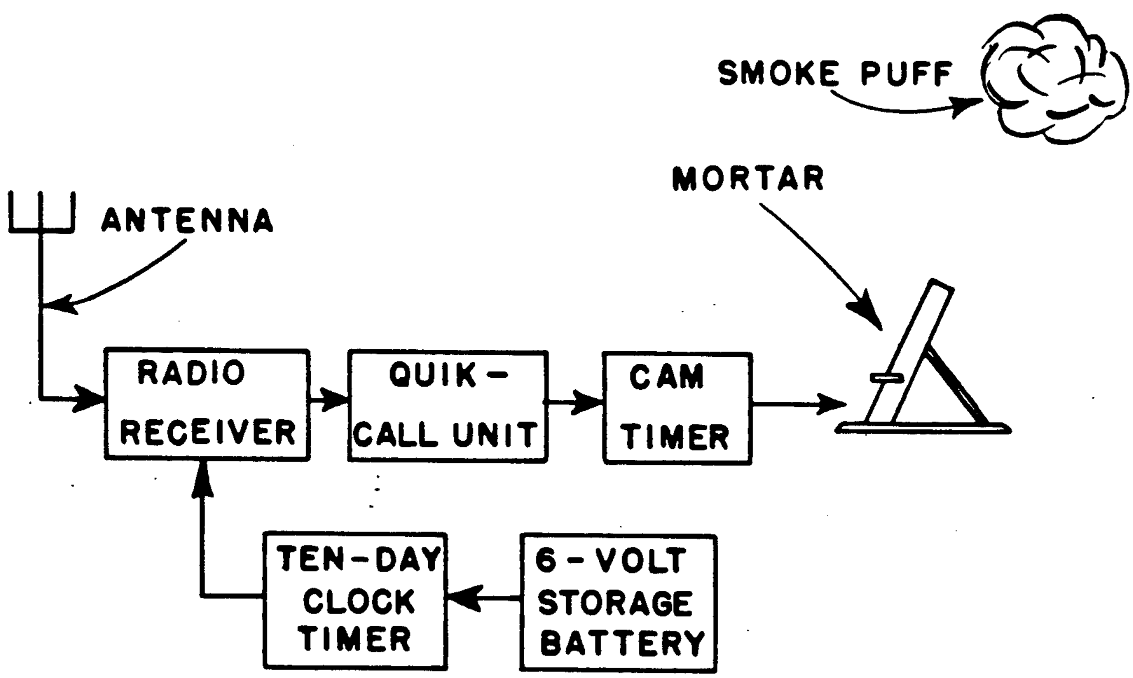


Fig. 4.3—Schematic diagram of the raft radio receiving system.

[redacted]

receiver unit consisted of the receiver, vibrator power supply, and tone-code selector, all mounted in one waterproof case. The tone-code selector was the Motorola Quik-call unit designed to receive the signal from the tone generator at the transmitter site.

When a trigger signal arrived at the receiver, it was demodulated, and the audio tone code entered the Quik-call unit where it caused a small relay to close. Closure of the Quik-call relay energized the motor in a cam timer which was installed inside the receiver case, causing eventual closure of a microswitch in the cam timer. This switch set off the mortar. The delay introduced by the cam timer was adjusted to produce a smoke puff just prior to the arrival of the shock wave at each station. Figure 4.3 is a schematic diagram of the receiving system.

4.1.3 Setup Procedure

Prior to Mike Shot, the receiving assemblies were set up in the tent at the base of the 125-ft photographic tower on Elmer. The assemblies were tested by sending signals from site zero on Flora and observing whether or not they triggered. Satisfactory operation was obtained on all assemblies at this range, which was somewhat greater than the maximum required for the shot.

Prior to King Shot, the receivers were lined up with a signal generator located on Yvonne, consisting of a Motorola tone generator and the low-level stages of a 10-watt transmitter. The signal was fed through a 10- to 51-db attenuator. With this device it was possible to determine the relative sensitivities of the eight systems checked and detect those markedly below the best in performance. Some components were serviced and improved several decibels, even though they appeared to work normally when checked with the signal from site zero. With this test setup it was determined that the receivers were capable of operation with about 15 db less signal than was received from the transmitter.

On K−1 day the rafts, with equipment installed, were transported on board an LCT to their stations, and the 10-day wind-up clocks were set up to turn on the receivers at H−1 hr. Since there were several postponements of King Shot, it was necessary to reset these clocks.

4.1.4 Operation and Recommendations

Operation of the system was satisfactory on both Mike and King Shots. One mortar failed to fire on Mike Shot due to failure in a soldered joint in the receiver. There was also one failure on King Shot, but its cause was not determined since the equipment was destroyed by the blast.

4.2 RADIO FIRING LINK

The radio firing link was designed to enable the firing party to control the arming and firing (or postponement, if necessary) of the shot from aboard the U. S. S. *Estes*, some 30 miles at sea. Facilities were added to permit remote-control training from the U. S. S. *Estes* of two microwave television antennas located at site zero.

The basic system consisted of three Motorola remote switching links, each consisting of a vhf f-m transmitter and receiver. The radio-tone generator rack is shown in Fig. 3.7, and the three radio-transmitter racks are shown in Fig. 4.4. The transmitter was modulated with a pair of audio tones, and equipment at the receiver output threw switches corresponding to the tones received.

It was possible to perform several functions by selecting the proper pairs of tones for transmission. As finally set up, two of three links performed four functions each, and the third provided three functions.

The functions performed by the three links were as follows:

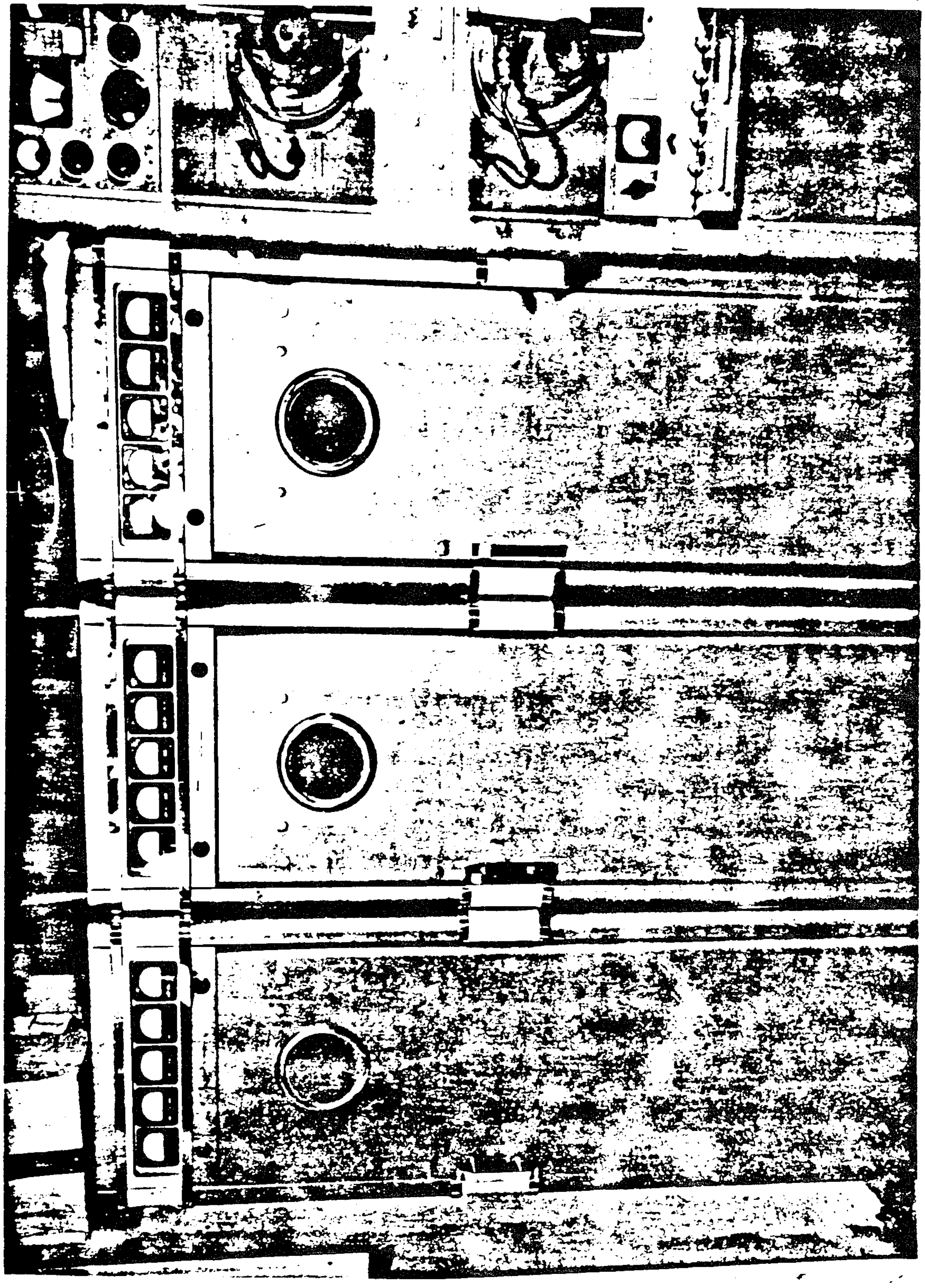


Fig. 4.4—Radio-tone transmitter racks located in the control room on the U.S.S. *Bates*.

[redacted]

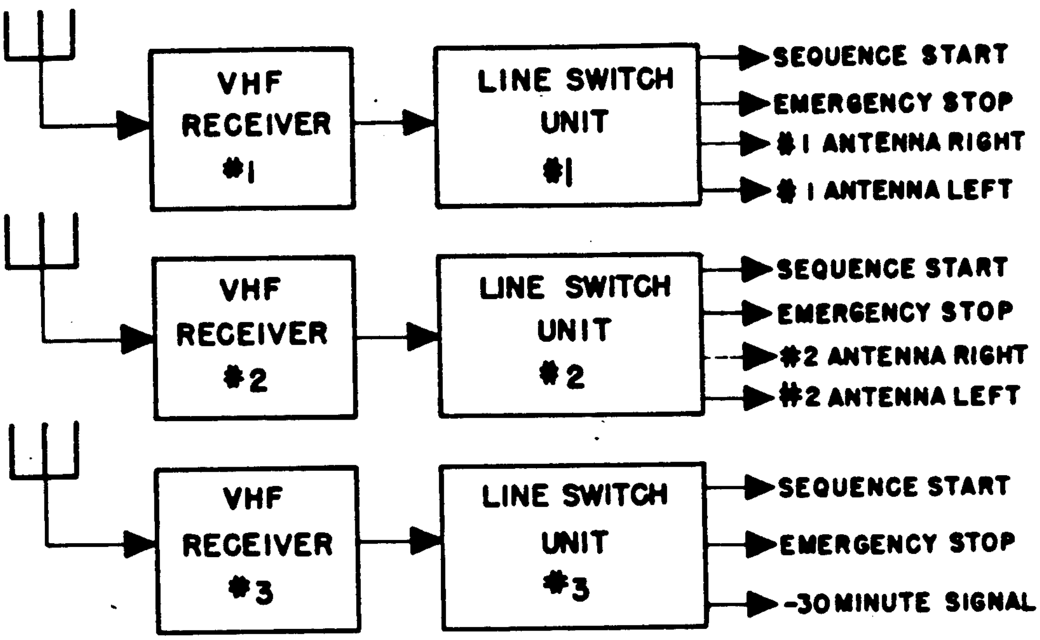


Fig. 4.5—Block diagram of tone-transmitter installation on the U.S.S. *Estes*.

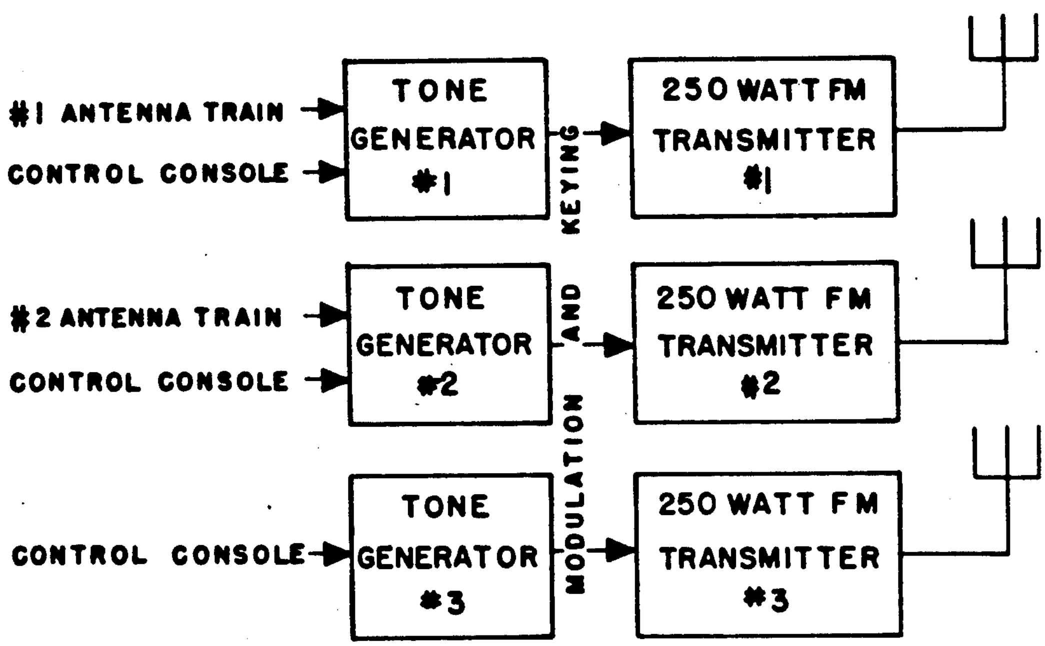


Fig. 4.6—Block diagram of radio-tone receiver installation at site zero on Flora.

[redacted]

[redacted]

Link No. 1—(1) sequence start, (2) emergency stop, (3) No. 1 antenna train right, and (4) No. 1 antenna train left

Link No. 2—(1) sequence start, (2) emergency stop, (3) No. 2 antenna train right, and (4) No. 2 antenna train left

Link No. 3—(1) sequence start, (2) emergency stop, and (3)−30-min signal

The signals for sequence start and emergency stop were transmitted on all three links simultaneously. To ensure absolute reliability, the emergency stop circuits were wired to permit any one of the three links to prevent the shot from going off. A measure of security from spurious triggering was obtained on the sequence start by designing that circuit to require signals from any two of the three links rather than one signal alone. However, the 30-min signal was transmitted by only one transmitter. The signals for sequence start, emergency stop, and 30 min were sent by pressing buttons on the control console on the U. S. S. *Estes*.

The antenna-train signals (four altogether) were sent by the operator at the antenna control rack. Two lever switches, installed in a small subchassis mounted on the rack, were thrown to the left or right to train their associated television antennas clockwise or counterclockwise. This assured the television link of maximum signal regardless of the bearing of the ship from site zero.

The firing link equipment aboard the U. S. S. *Estes* was installed by personnel from Mare Island Naval Shipyard, Vallejo, Calif., under the supervision of EG&G personnel. A block diagram of this installation is shown in Fig. 4.5.

The receiving equipment was set up and installed at site zero by EG&G personnel. The three radio receivers and line-switch units were mounted in a single 7-ft rack, together with a bank of relays which were used between the line-switch units and the loads. The antennas were mounted on the 375-ft tower. Figure 4.6 shows schematically the installation at the zero site.

The tone generators at the transmitters and the line-switch units at the receivers were modified considerably to adapt them to the requirements of the system. The tone generators were rewired to select tones with d-c relays instead of switching audio voltages at the selector buttons. They were also changed so that no tone was used for more than one function. This provided additional assurance against spurious operation. Two of the line-switch units were modified to perform a fourth function; these units normally provide only three functions.

The system was lined up in the field as to frequency and tone levels, the tone levels being set at the transmitter to get certain voltages at the receiver end of the link. This work was speeded up by making use of the television link between Flora and the U. S. S. *Estes*. The reading on the voltmeter at site zero was televised to the U. S. S. *Estes*, thus enabling the technician aboard to view the meter as he made his adjustments.

During dry runs the system proved effective to ranges of 37 miles, thus exceeding the calculated range for the line of sight by about 3 miles. No serious difficulties were encountered in the installation of this equipment, and the final performance was satisfactory.

[redacted]

[redacted]

CHAPTER 5

BLUE BOXES AND FIDUCIAL MARKERS

5.1 BLUE BOX

5.1.1 General

The need was encountered on Operation Ivy, as on previous operations, for a small compact photoelectric equipment capable of synchronizing other equipment with the burst at zero time with millisecond accuracy. Previous tests on Sandstone, Greenhouse, and those held at the Nevada Proving Grounds have proved the Blue Box to be a reliable equipment for this purpose.

Since many experimenters who had use of the Blue Box were unable to obtain a-c power at their stations, EG&G provided a d-c box to supplement the a-c type. The d-c type operated from power obtained from four 45-volt dry-cell batteries housed in the chassis.

The a-c Blue Box provides two types of output: (1) a pulse output of approximately 200-volt amplitude and long duration and (2) a three-wire relay output with one circuit normally open and the other normally closed. This unit must be reset after it is once triggered. The d-c Blue Box provides only the latter output, a three-wire output, one circuit open and one closed.

Both models are small, easily handled, and moisture resistant. Four mounting ears are provided in the chassis for securing the instrument to a rack or shelf. The a-c model is pictured in Fig. 5.1 and the d-c model in Fig. 5.2.

5.1.2 A-c Blue Box, Type A-1

Figure 5.3 shows the schematic diagram of the type A-1 Blue Box. A 929 phototube (V101) with a 270K cathode load resistor is coupled to a 2D21 gas-filled thyratron (V102). The V102 is normally nonconducting but is turned on when a light pulse of sufficient intensity and with a sharp leading edge strikes the cathode of the 929 phototube. A peak light of approximately 2 lumens on the cathode, with a rise time of 3 to 10 μsec, is sufficient to trigger the 2D21. Once the 2D21 is made to conduct, it will conduct until the plate voltage is removed. Pressing S102 (reset) removes the plate voltage and allows the grids, each of which has a normal bias of −16 volts, to take over and stop conduction until another light pulse strikes the 929 (V101) cathode.

When the 2D21 is triggered by the phototube (V101), a pulse of approximately 200-volt amplitude appears at J102 (pulse output), the neon light (reset indicator) turns on, the relay contacts A and B close, and contacts B and C open at J103 (relay output). The pulse output occurs within 50 μsec after the beginning of the light pulse, reaches an amplitude of at least 200 volts, and then drops off gradually to approximately 100 volts. The relay closes within 2 msec after the light pulse and remains closed until the reset switch is pushed. The neon indicator comes on coincident with the pulse output and remains on until the reset switch is pushed.

[redacted]

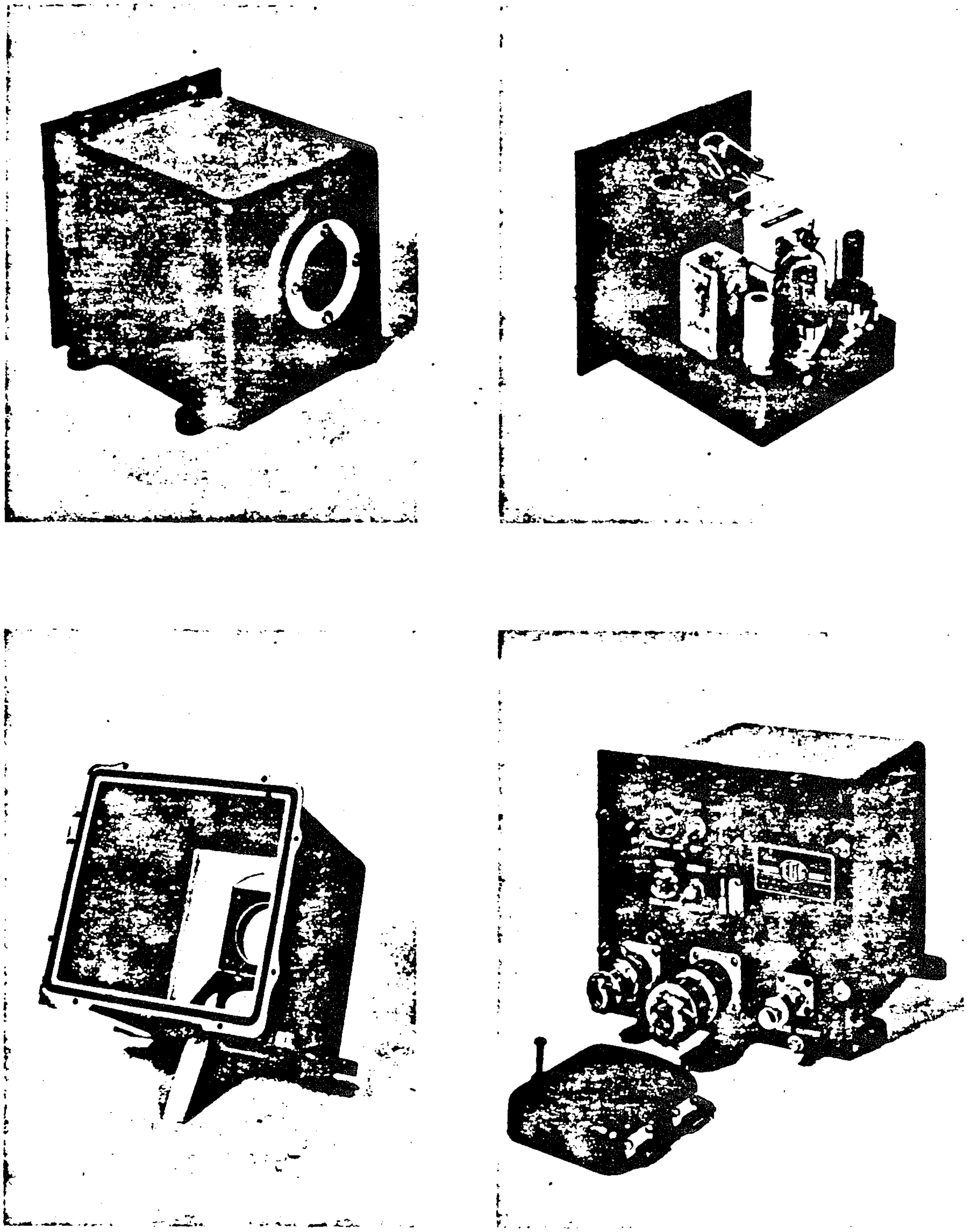


Fig. 5.1—A-c Blue Box, type A-1.

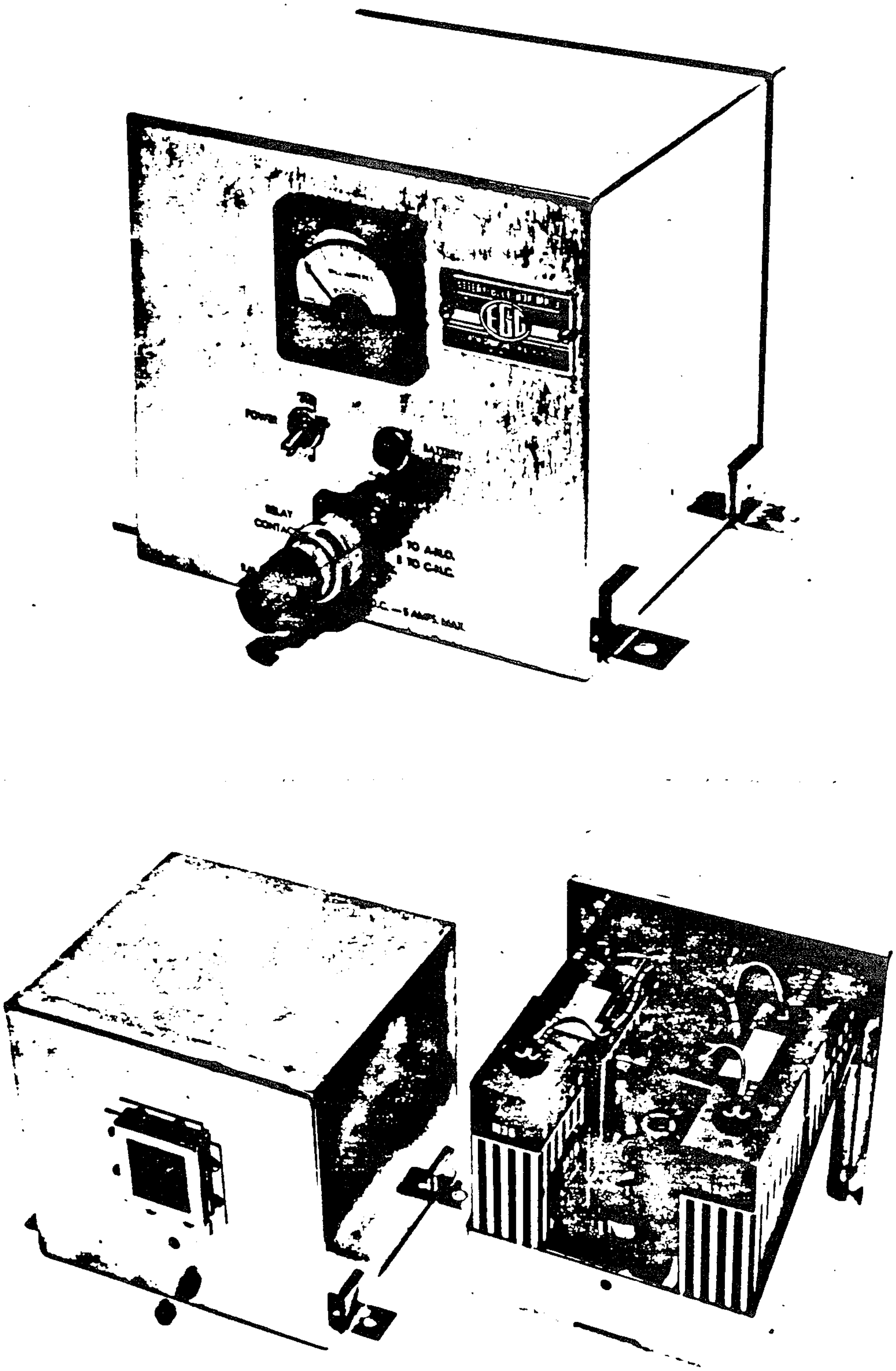


Fig. 5.2—Battery Blue Box, Mark III.

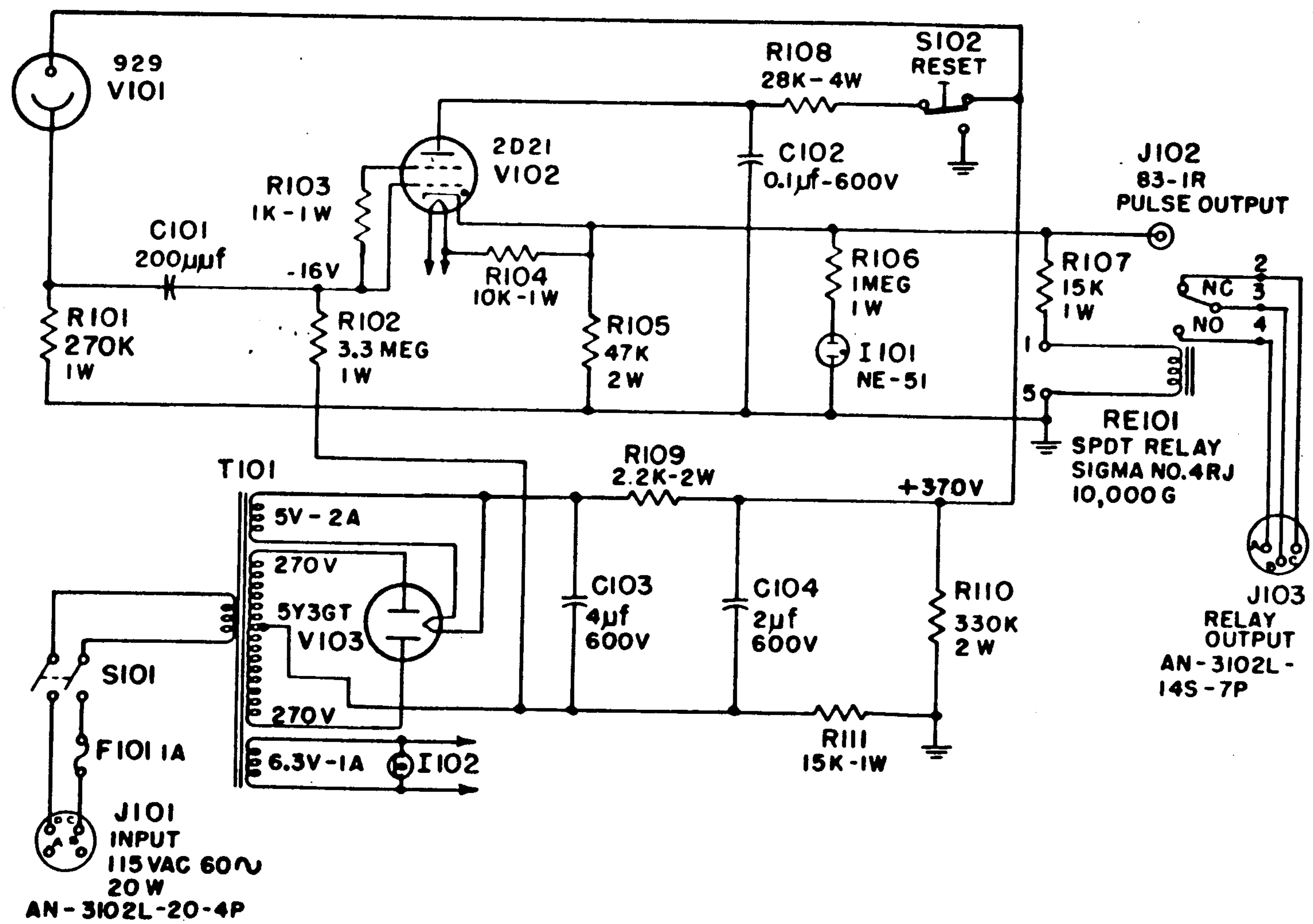


Fig. 5.3—Schematic diagram of Blue Box, type A-1.

[redacted]

The power-supply circuit is a conventional full-wave rectifier with a condenser-resistor filter. Both positive and negative voltages are taken from this power-supply circuit.

5.1.3 D-c Blue Box, Mark III

The wiring diagram of the battery-operated Blue Box is shown in Fig. 5.4 and consists basically of the following components:

1. A 180-volt power supply, consisting of four 45-volt batteries in series.
2. A 929 phototube which is actuated by the light flash.
3. A 5823 trigger tube, normally nonconducting, which is caused to conduct by the application of the electrical signal from the phototube on its trigger electrode.
4. A sensitive relay in the plate circuit of the trigger tube which is energized when the trigger tube is conducting. A three-pin connector is furnished from which may be selected either a contact closure or a contact opening, as the test equipment requires, one terminal being common to both circuits.

In addition, there is incorporated in the unit a meter which has the dual function of battery condition indicator and unit operation indicator. Conduction of the phototube due to ambient light level is reduced to a safe value for ordinary conditions by the insertion of a wire screen filter in the case aperture, and a heat-absorbing window in the aperture prevents damage to internal components from direct infrared radiation. Mechanically the unit is housed in a gasketed sheet-metal case measuring roughly 8 in. wide by 7 in. high by $8\frac{1}{2}$ in. deep as viewed from the control panel. Four mounting ears are provided, two to a side, at the bottom surface of the case for securing the unit to a rack or shelf.

Power is furnished by four 45-volt radio B batteries (Burgess M-30 or equivalent) in series, giving 180 volts for the anodes of the phototubes and trigger tube. With the switch on and under ambient light conditions, the battery drain is negligible and practically shelf life may be realized from the batteries. When the unit is energized, battery life should be about 24 hr.

The circuit is so designed that when the unit is caused to operate by a high-intensity light pulse the relay is energized and remains energized until manually reset by momentarily shutting off the power switch. The relay hold-in current has been adjusted to a minimum value, commensurate with reliable continuation of relay hold-in, in the interests of prolonged battery life. To prevent early battery exhaustion, it is important that the unit not be allowed to remain in the energized state longer than absolutely necessary.

The sensitive relay operates within about 10 msec or less from initiation. The contacts have limited current-carrying capacity, being limited to about 5 amp at 24 d-c volts or 115 a-c volts noninductive.

5.1.4 Operation

The Blue Box is relatively simple to operate. The instrument is connected to its power source (in the case of the d-c model the batteries are built in the chassis) and positioned so that the photocell window is directed at the zero point. A filter (ND2 in the a-c type and a wire screen in the d-c type) has been inserted in a filter holder in order to protect the photocell from direct sunlight and ambient light. However, in the event that the direct rays of the sun fall on the phototube, suitable shading should be provided. The desired output cable is connected, the instrument turned on, and it is ready to trigger upon receipt of the proper light pulse.

Enough units were shipped to meet the known requirements, plus additional units to meet replacement estimates and additional demands encountered in the field. These units were shipped to a central site (the Administrative Compound) on Elmer where they were unpacked, and each was carefully tested in the following manner before issuance: A General Radio

[redacted]

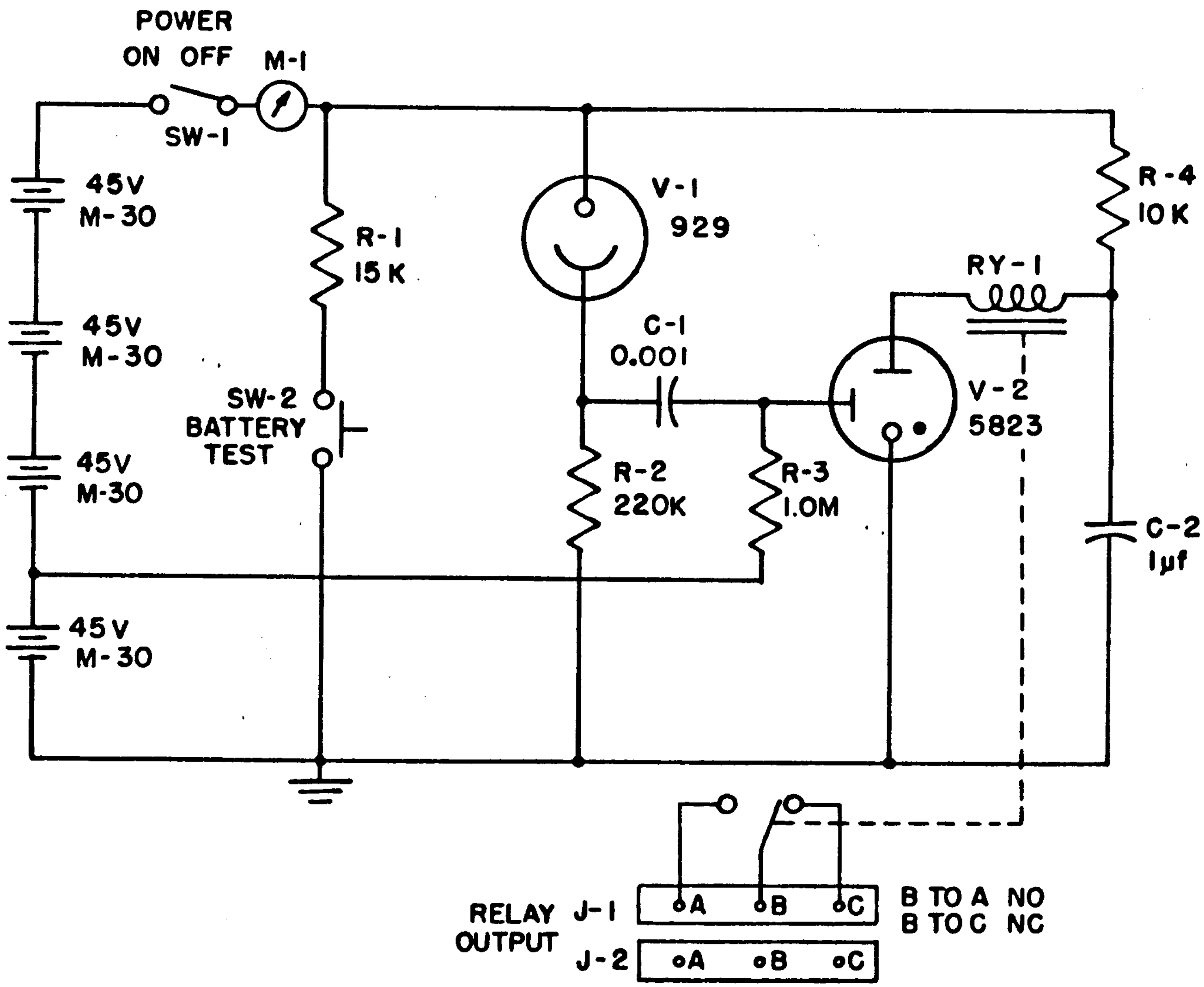


Fig. 5.4—Wiring diagram of battery Blue Box, Mark III.

[redacted]

[redacted]

Strobolume Type 1532-A was positioned so that its light was directed at the Blue Box. After both instruments had been allowed to warm up for several minutes (in the case of the d-c Blue Box no warm-up was necessary), the Strobolume was flashed. The Blue Box should operate until the distance between the two instruments is 8 ft.

When these units were distributed to experimenters, it was cautioned that they should be protected from both sun and rain as much as possible. Although they are dripproof, there is no pretense that they are waterproof, and the hard driving rain encountered preceding shot days penetrated the chassis and undoubtedly caused some failures on shot day. If the Blue Boxes were subjected to direct sunlight for any length of time, the heat generated within the chassis would have a harmful effect on the components, especially the dry-cell batteries in the d-c model and the cathode coating of the phototube. If the units were to be used at a distance greater than 15 miles from the zero point, the users were advised to remove the filter and use the units minus the filter. These directions are deemed important, and it is believed that, if they had been universally complied with, the number of failures on shot day would have been reduced substantially.

5.1.5 Conclusions and Recommendations

Because of the slow rise of light on Mike Shot (about 8 msec), a number of Blue Boxes did not trigger. The coupling time constant between the photocell and the 2D21 in the a-c Blue Box is 660 μsec. In order to transfer a pulse through this circuit, the rise time of the pulse should be short compared to 660 μsec. Since the rise time of the light was so long, it is not surprising that a number of Blue Boxes failed on Mike Shot. In the future the coupling capacitor will be raised when a long-rise-time light pulse is expected. On this particular shot the long rise time was not anticipated. The shot-time-constant coupling circuit is used in the normal Blue Box because a fast rise is normally expected, and a short time constant acts to prevent extraneous slow-rising light pulse from triggering the Blue Box early.

Since Blue Boxes are built to be moisture resistant and not watertight or hermetically sealed, it is mandatory that they be covered or used inside a building. There are high-impedance circuits inside a Blue Box which must be free from moisture in order for the Blue Box to function properly. Any time a Blue Box is left in the open where the sun and rain can strike it, there is a great probability that the Blue Box will not operate properly. It is also mandatory that the ND2 filter be removed if the Blue Box is to operate at great distances from zero. If the Blue Box is to be used looking toward the sun and the filter is removed, a tube should be used to limit the field of view, and the tube should be aligned toward zero.

5.2 FIDUCIAL MARKER, TYPE B

The type B fiducial marker was designed for use when millisecond accuracy was not sufficient and microsecond accuracy was required. The units used on Operation Ivy were essentially the same as those used on Greenhouse.[1] EG&G used this type of marker to trigger the Rapatronic cameras, the Brixner camera shutter, and the image converter and to furnish zero markers for the Eastman cameras and the General Radio cameras.

Results obtained with this instrument on Mike and King Shots were excellent. All the units used operated properly and at no time showed any signs of trouble.

REFERENCE

1. Greenhouse Report, Annex 1.11, Timing and Firing and Fiducial Markers, WT-99.

[redacted]

Appendix

WIRING DIAGRAMS

[redacted]

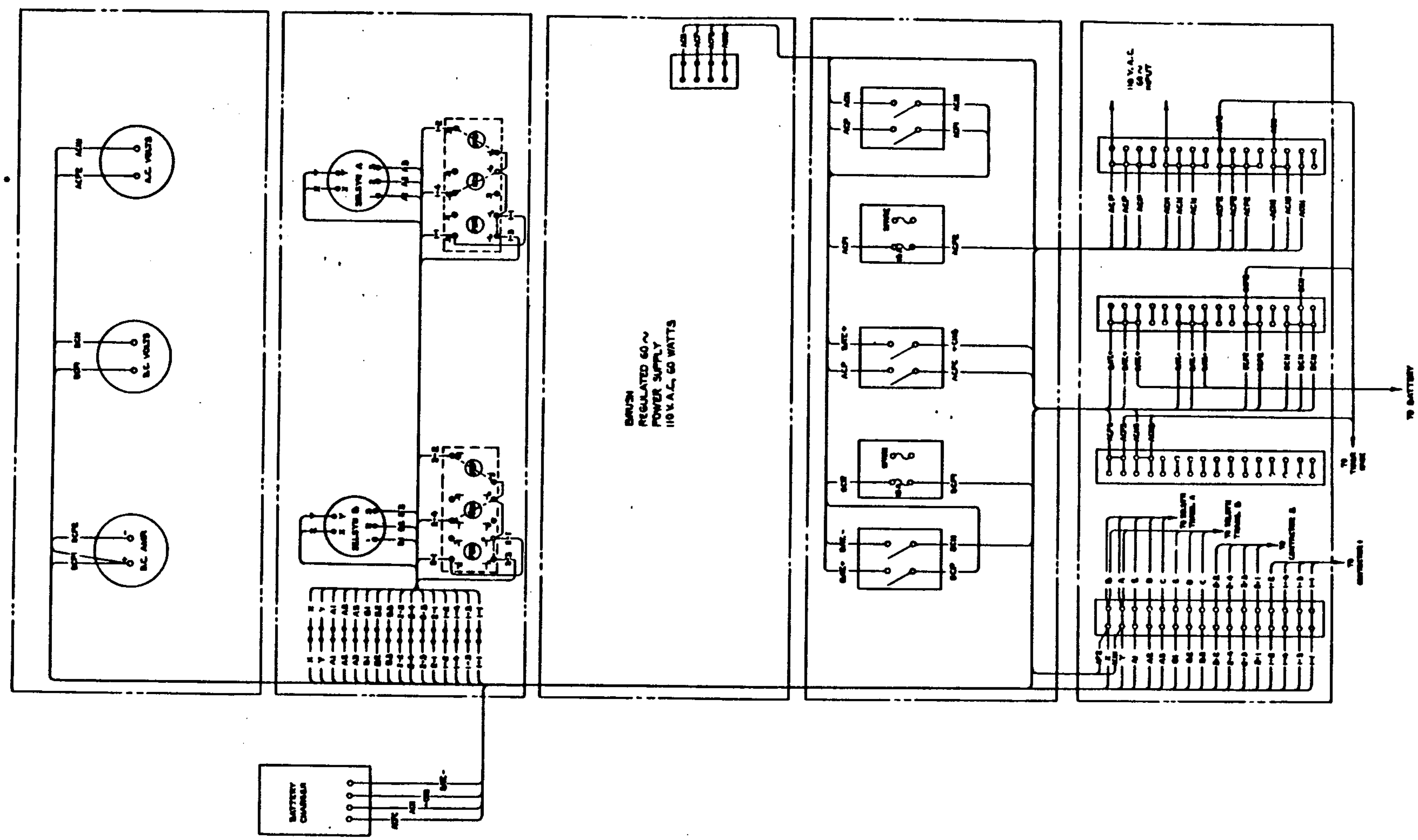


Fig. A.1—Wiring diagram of power rack, control station.

[redacted]

[redacted]

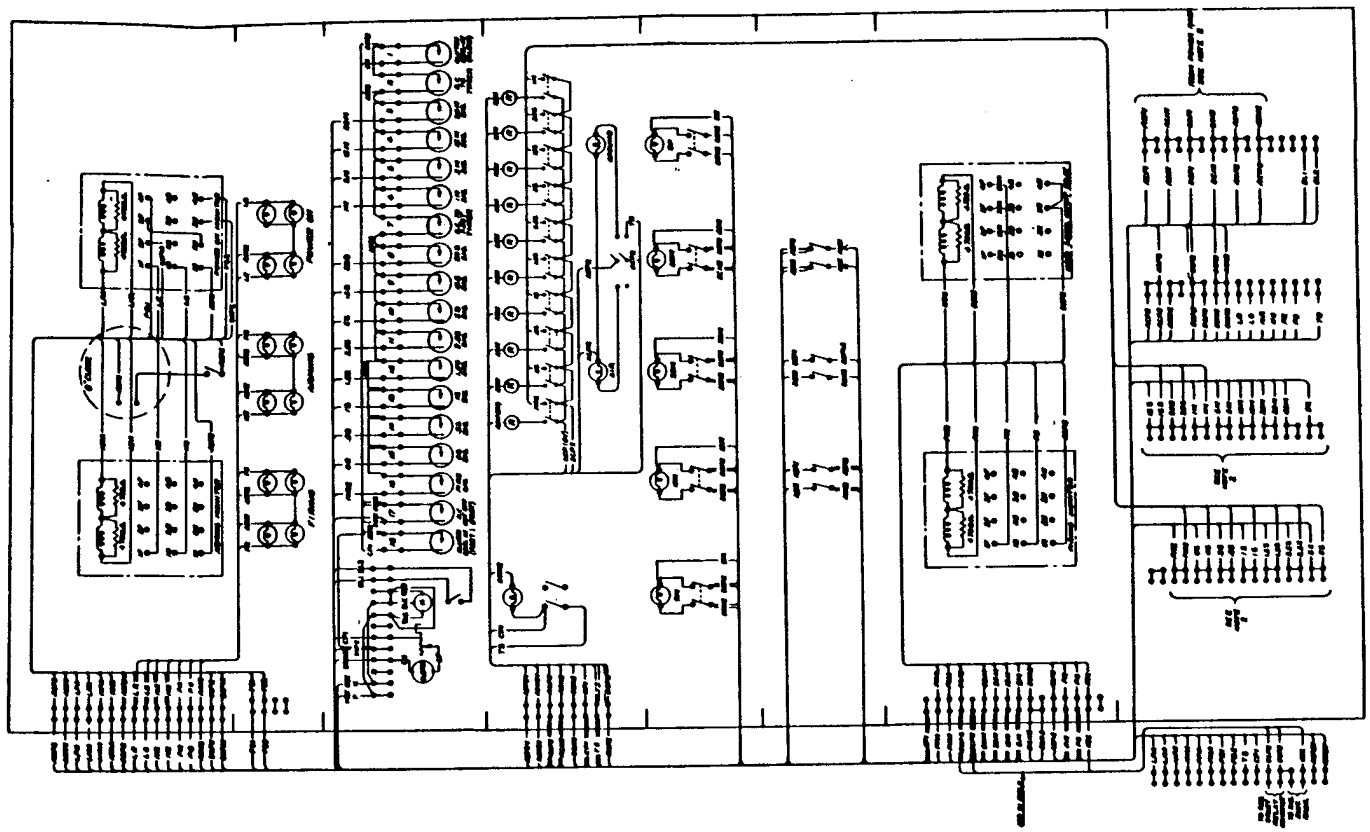


Fig. A.2—Wiring diagram of timer rack, control station.

[redacted]

[redacted]

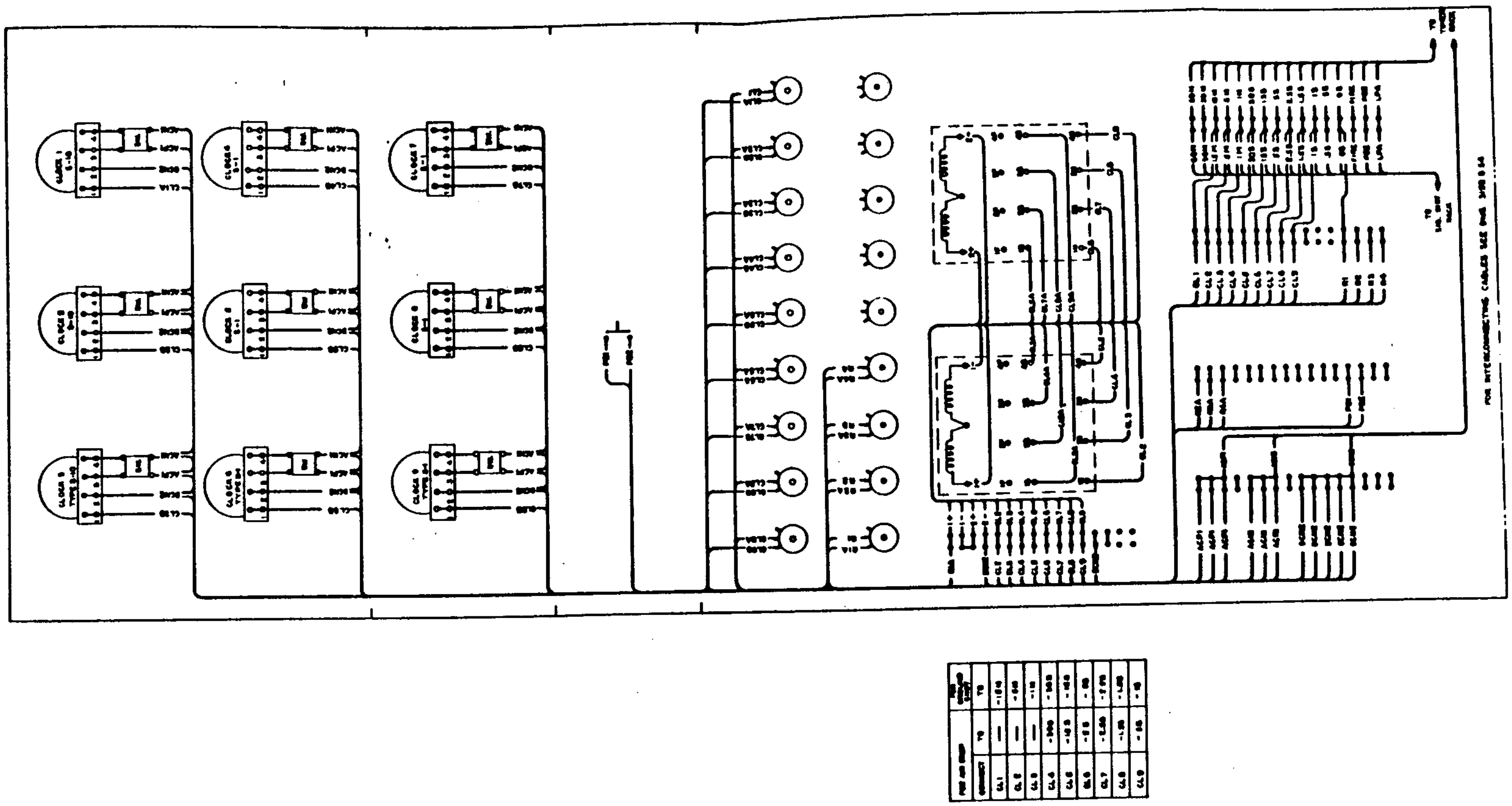


Fig. A.3—Wiring diagram of test rack, control station.

[redacted]

[redacted]

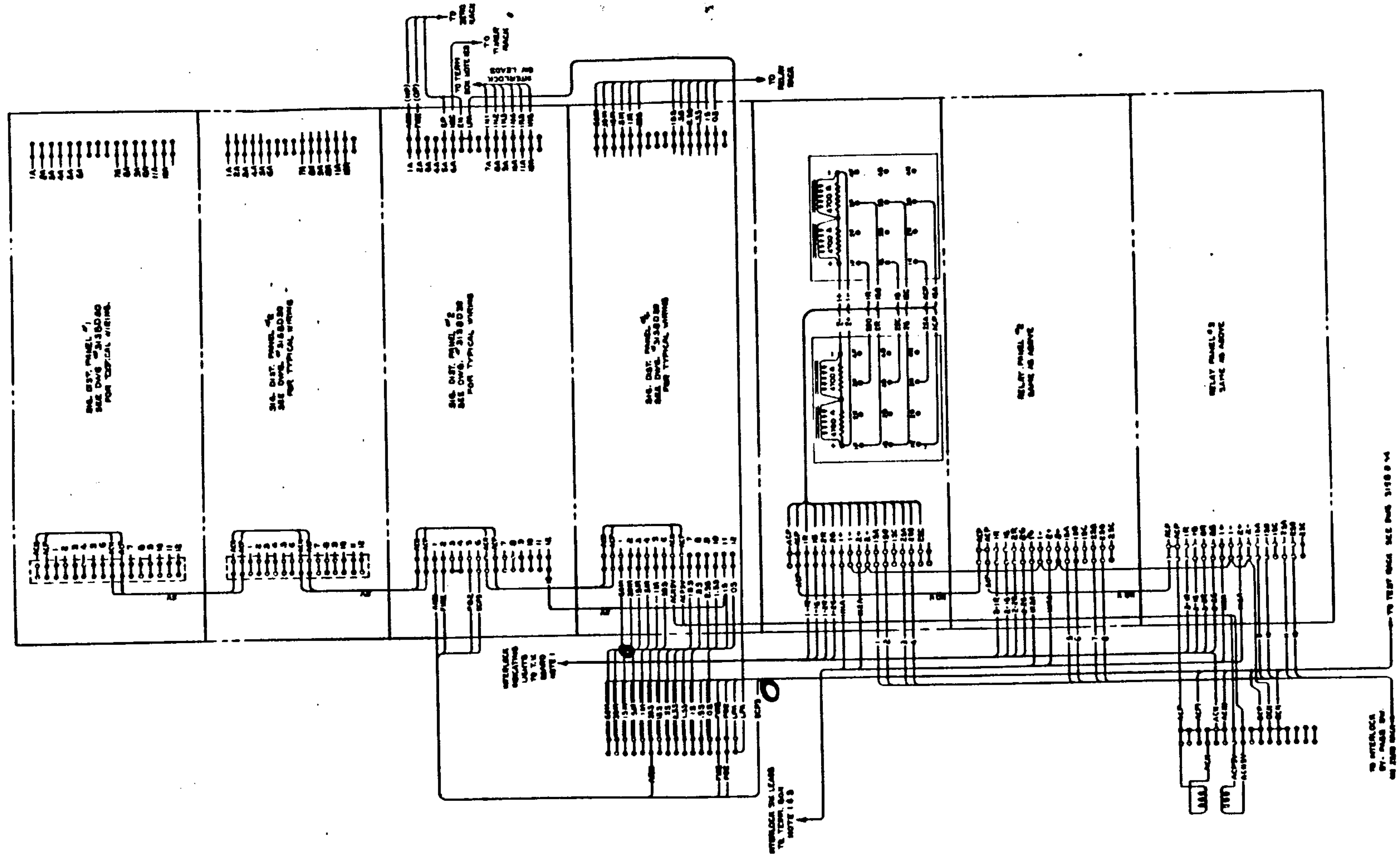


Fig. A.4—Wiring diagram of signal-distribution rack, control station.

[redacted]

[redacted]

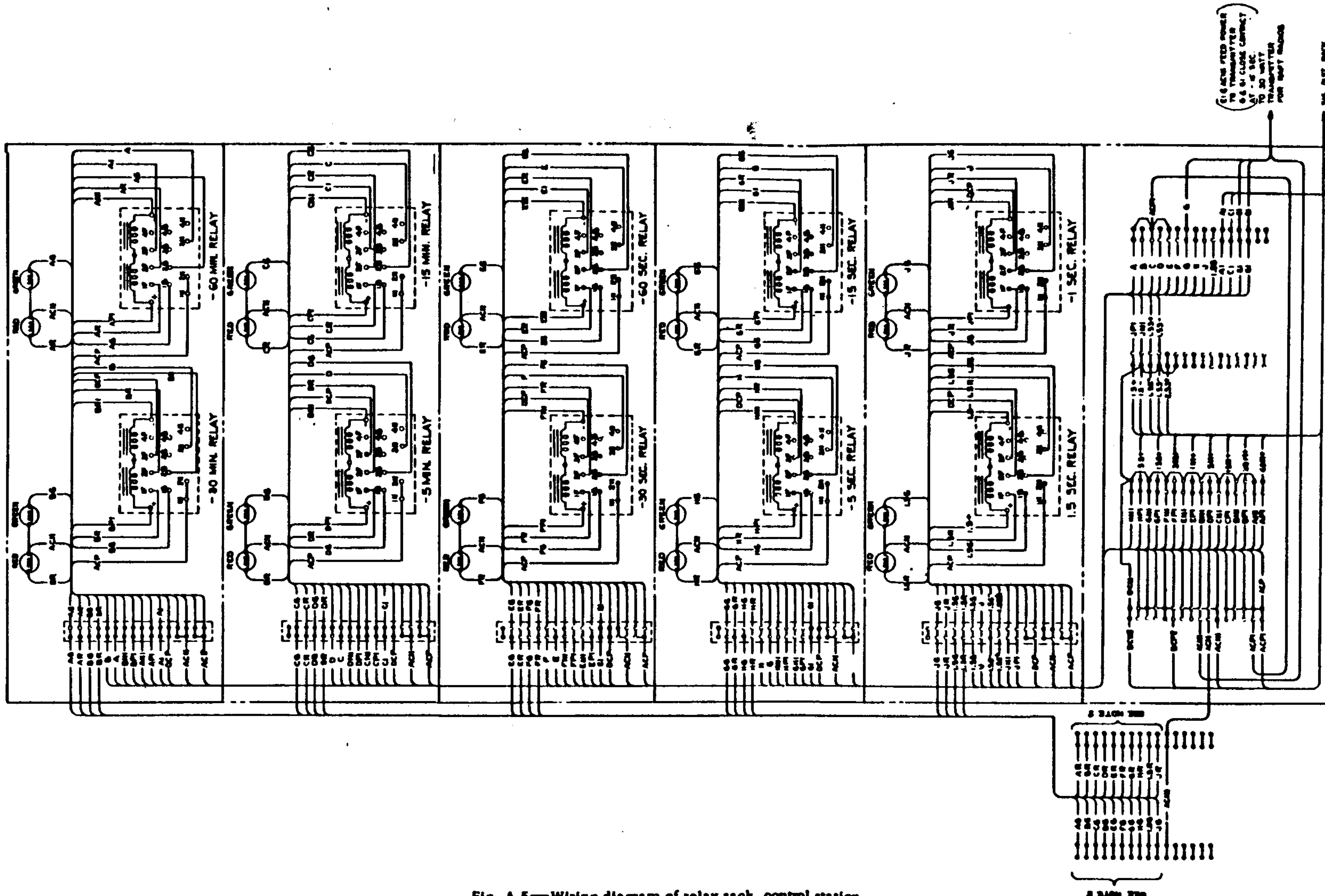


Fig. A.5—Wiring diagram of relay rack, control station.

[redacted]

[redacted]

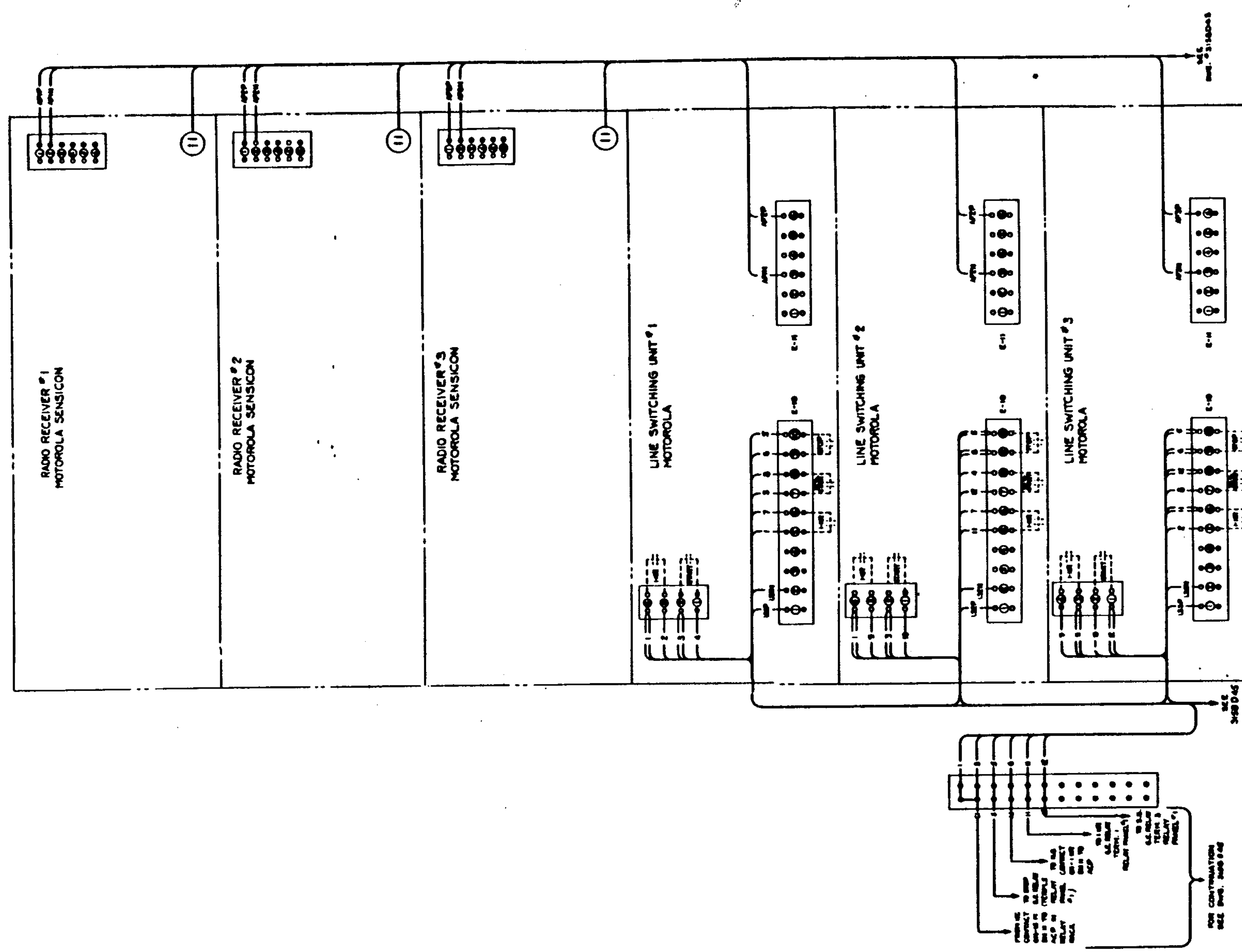


Fig. A.6—Wiring diagram of radio relay rack, receivers, and line-switching units, control station.

[redacted]

[redacted]

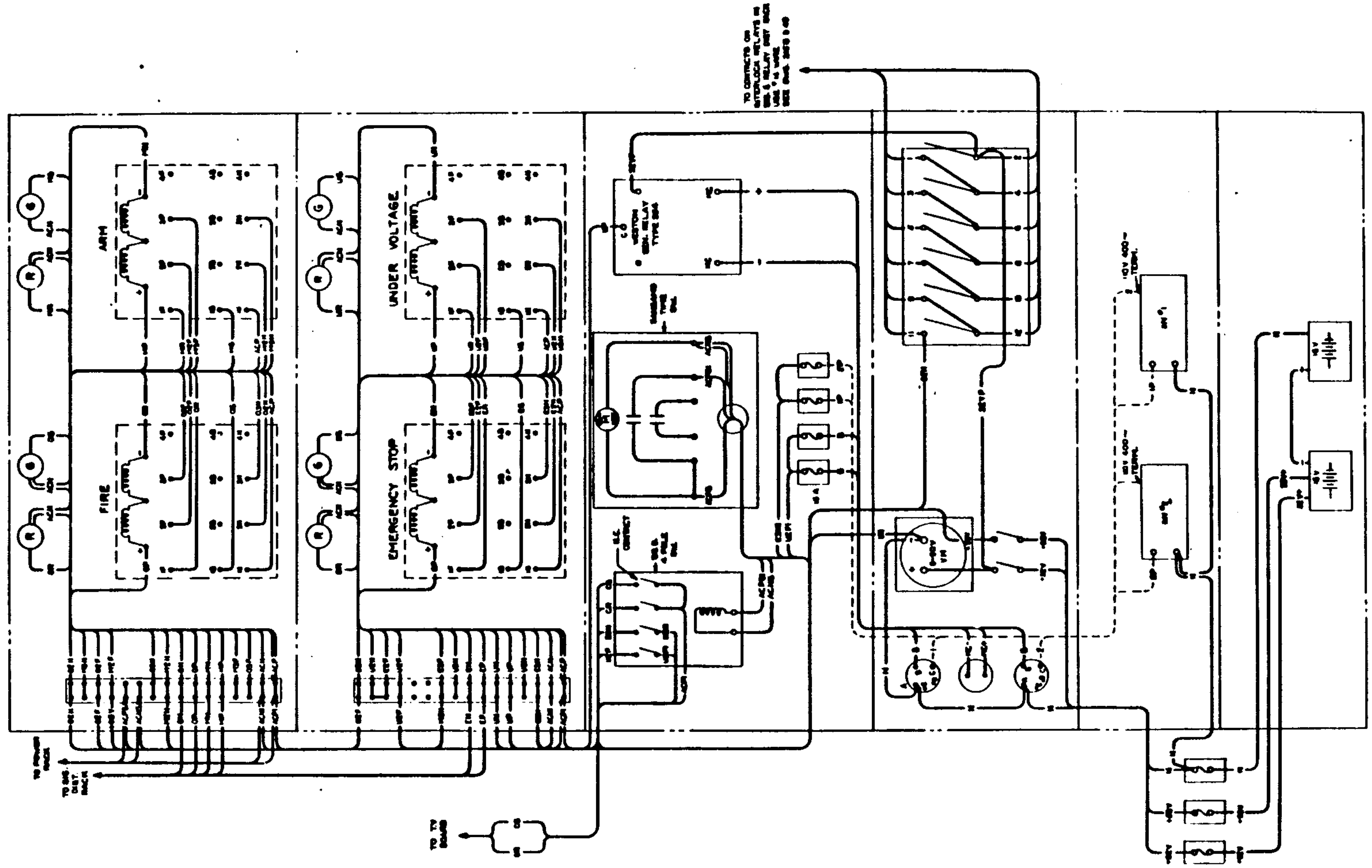


Fig. A.7—Wiring diagram of zero rack, Mike Shot.

[redacted]

[redacted]

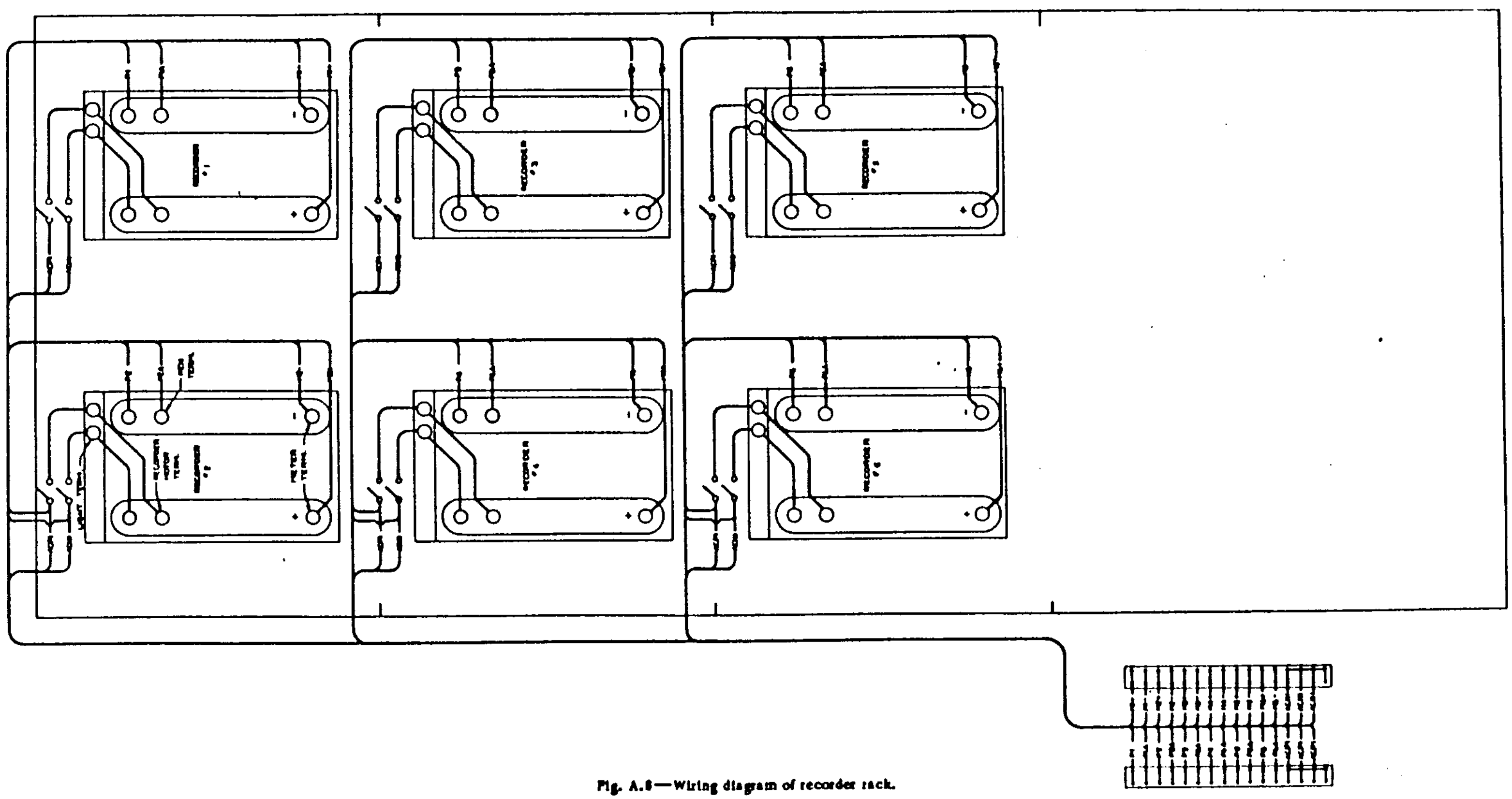


Fig. A.8—Wiring diagram of recorder rack.

[redacted]